ABSTRACT

Dissertation Title: HAVING THEIR SAY: EIGHT HIGH-ACHIEVING AFRICAN-AMERICAN UNDERGRADUATE MATHEMATICS MAJORS DISCUSS THEIR SUCCESS AND PERSISTANCE IN MATHEMATICS

Roni M. Ellington, Doctor of Philosophy, 2006

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Education, Policy and Leadership

The purpose of this study was to identify and understand the factors that influence high-achieving African American mathematics majors to persist and succeed in mathematics. The major research question guiding this study was: What perceived factors contribute to high achieving African-American junior and senior mathematics majors' decision to persist and succeed in mathematics through college? This study also sought to answer the following sub questions:

1. In what ways do African- American high achievers perceive the role of the family, educational institutions, and the community in their success and persistence in mathematics?
2. How do they perceive their own role in their success and persistence in mathematics?

This study sought to understand which factors shaped the participants' decision to persist and succeed in mathematics. This study employed interpretive case study methodology in which interview data from eight high-achieving African-American mathematics majors were collected, transcribed and analyzed. The study employed elements from social, cultural, and personal factors identified in mathematics education research and factors from the college persistence literature relating to African-American students.

Findings indicate that parents played an essential role in providing these high achievers with early learning experiences and advocating for them in school environments. By doing this, the students were placed in advanced academic programs by third grade that gave them access to caring teachers who held high expectations for them and provided them with challenging mathematics experiences.

Participating in accelerated academic programs, having access to advanced mathematics coursework, and having peer support and teacher encouragement were factors that shaped their mathematics success in high school. Participants were involved in college scholarship programs that provided them with a variety of resources, particularly faculty and peer support that were key factors to their success and persistence as mathematics majors. The participants' social consciousness and spirituality were key factors underlying their success and persistence in mathematics, particularly in college.

Implications for practice, policy and research are presented.

HAVING THEIR SAY: EIGHT HIGH-ACHIEVING AFRICAN- AMERICAN UNDERGRADUATE MATHEMATICS MAJORS DISCUSS THEIR SUCCESS AND PERSISTENCE IN MATHEMATICS

By

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Dissertation submitted to the Faculty of the Graduate School of the University of Maryland, College Park in partial fulfillment
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DEDICATION

In Memory of my mom and dad-

Thanks for giving me the tools to thrive in the world

I love you

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It takes a village to raise a child and an even larger one to support me through the dissertation process. I would like to first thank God for the strength and courage to complete this project. I want to take this opportunity to thank my family and friends for all their support, encouragement and love.

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CHAPTER I
INTRODUCTION

Introduction

African-Americans are considerably underrepresented in the mathematics pipeline at all levels (Anderson, 1990; Bailey, 1990; Hall & Krammer, 1987; Jabrill, 1990; Johnson, 1984; Oakes, 1990; Powell, 1990) Given the importance of mathematics and the lack of participation of African Americans, there is a growing interest in understanding the experiences of students that excel in mathematics, particularly those who pursue undergraduate degrees in the discipline (Copper, 2000; Figgers, 1997; Grandy, 1998; Hrabowski, Maton & Greif 1998; 2002; Kirst, 1993; Moody, 1998; 2000; 2001). Guided by social and cultural factors identified in mathematics education research and the success and persistence literature in higher education, this study seeks to understand high achieving African American students' family, educational, communal, and personal experiences and their perceived impact on their persistence and success in mathematics through college.

In this chapter, I will outline the problem, provide a rationale for this study, and briefly discuss the gaps in the literature and the specific conceptual framework guiding this study. This chapter will end with the research questions that guided this study and a brief overview of the methodology employed in this study.

Statement of the Problem

Because of a history of low performance, cultural insensitivity, and negative experiences in mathematics classrooms, there are few numbers of minority students who pursue rigorous mathematics coursework and eventually complete degrees in mathematics and related disciplines (Mathews, 1984; Oakes, 1990). Twenty-percent of

all high school sophomores express interest in science and engineering careers compared to only 10 percent of minority sophomores (National Science Foundation, 1991). Consequently, African-Americans, Hispanics and Native Americans make up approximately 18 percent of the United States population, but comprise roughly 2.2 percent of the scholars studying science and engineering. African-Americans constitute less than 3 percent of scientists, mathematicians and engineers (Jibrell, 1990). Kenschaft (1993) gives startling statistics that highlight the alarming state of affairs for African Americans specifically in mathematics. She reports that in 1989 –90, 401 American citizens received doctoral degrees in mathematics, 4 were African-American and only one was an African- American woman (p 1067).

The above statistics are disturbing given that many of the country's emerging labor markets are in science, technology, engineering, economics and manufacturing, all of which require a significant amount of mathematical literacy. Women and minorities will comprise a higher percentage of the nation's workforce, and this workforce will need science and mathematics literacy more than ever before (Anderson, 1990; Johnson, 1984; King, 1995; NCTM, 1988; 2000; Oakes, 1990). At primary and secondary levels, students of color will constitute over 40% of the total population in the year 2000. This is up from 30% in the 1990's (King, 1995; Mathews, 1984). However, many of these students will not enter the science, mathematics and engineering workforce. Many would argue that this is due, in large part, to their inadequate interest and preparation in mathematics (Bailey, 1990 Oakes, 1990; Sells, 1980). If the numbers of minorities, specifically African-Americans, in mathematics and related fields remain at alarmingly low levels, a large segment of the potential labor force will be eliminated from the

applicant pool, creating greater gaps in the earning potential between African- Americans and their white counterparts.

In the1980s and 1990s, African American students did experience some gains in mathematics achievement, course taking and persistence (Johnson, 1984; Tate, 1997); however, many of these gains were recorded in K-12 education and merely reflected African American students being able to perform better on mathematics basic skills assessments. There was little progress made in the number of students taking advanced placement courses and college calculus, both of which are strong predictors that students will pursue higher-level mathematics courses and undergraduate degrees in mathematics (Johnson, 1984; Oakes, 1990; Tate, 1997).

Of those African-American students who do persist, many are not achieving to the highest levels, are severely "turned off" by mathematics, and struggle to "survive" in undergraduate mathematics classrooms. Some of the explanations given for this are that these students lack peer support (Seymour & Hewitt, 1997), a sense of belonging (Astin, 1982) and faculty role models and mentors (Brown, 1994; Thomas, Clewell and Pearson, 1992). They are also often perceived as having lower ability than their white counterparts (Brown, 1994). Seymour & Hewitt (1997) investigated the experiences of those minority students who switched from those who persisted in science, engineering and mathematics (SEM) majors. Their study found that both switchers and non-switchers reported that they disliked the straight lecture style format of their SEM classes and that the competitive, non caring environment of their science and mathematics classes affected their performance. These were among the key reasons they decided to switch to non-SEM majors. In addition, African-American students are not placed in rigorous and

accelerated mathematics coursework in high school. Hence, many African-American students are under prepared for rigorous mathematics coursework in college, which contributes to them leaving mathematics and related disciplines or dropping out of college all together (National Center for Education Statistics, 1990).

In addition to the need to cultivate African-American students' persistence in undergraduate mathematics classrooms, the mathematics community has a need for highly competent mathematics teachers and professors in our nation's schools and universities (Clark, 1990). The lack of highly trained mathematics educators is a direct result of a critical shortage of mathematics majors in our colleges and universities; hence, very few actually earn degrees in mathematics. For example, Seymour & Hewitt (1997) examined factors that had the greatest impact on students' decisions to persist or switch from science, mathematics and engineering majors into disciplines that were not science-based. This study found that SEM majors were more likely to switch to non-SEM fields. Only twenty-nine percent of mathematics majors remained in the major while sixty-two percent of entering math majors switched to non-SEM majors. The other nine percent remained in SEM related fields. This was the highest switch percentage of all the SEM disciples. Although SEM- based disciplines experienced a sharp decline in enrollment, mathematics majors experienced the sharpest decline. These numbers speak to the ongoing challenge to retain the most prepared students in the mathematics pipeline.

In the United States minorities, particularly African-Americans, fail to succeed and persist in mathematics relative to their white peers. Their lack of persistence in graduate education is particularly daunting. Cooper (2000) notes: "The numbers of black graduate students pursuing Ph. D's in mathematics are small, and the numbers of those

attaining the degree are tiny. In 1993, about one half of one percent of all this country's Ph. D's were earned by African-Americans; specifically, 5 of 1146 (p 179)." He goes on to mention that these numbers are typical. In fact, from 1986-95, only 58 of the 9520 Ph. D's in mathematics were awarded to African Americans (National Science Foundation, 1995). These numbers reveal that our nation will have very few African American professors in mathematics, which will have an adverse impact on our universities. As a result, African-Americans will not be adequately represented in the history and culture of mathematics. Consequently notable achievements in the discipline will not include African-Americans, which will have an adverse effect on future African-American mathematicians (Bailey, 1990).

The crisis in mathematics is so profound that the low numbers of African-Americans in mathematics programs challenges even those universities who have experienced some success at promoting the achievement and degree completion of African American students. In 1998, the University of Maryland's mathematics department had twenty-one black (African-American) graduate students, most of whom were pursuing the Ph.D. These numbers are high considering that all universities graduate five to nine African-Americans who earn the Ph.D degree in a typical year (Cooper, 2000). December 2000 was the first time in the University of Maryland's history that three African-American females earned their doctorates in mathematics. This is a monumental yet disturbing event. It is a testament to the fact that African American students continue to lag behind in their achievement and persistence in mathematics. So much so that they are still experiencing "firsts" in a field that is very critical to the economic and academic survival of our society.

The low numbers of high achieving mathematics majors produces serious challenges and problems for the nation. First, the nation must produce mathematics educators who are knowledgeable, competent and inspired, especially in schools serving African-American students. Research shows that students learn best from teachers who are culturally sensitive to their needs (Anderson, 1990; Ladson- Billings, 1995: Tate, 1995). Hence, well-trained African-American mathematics teachers serve an instrumental role in K-12 institutions. Secondly, colleges and universities need diverse colleagues in mathematics and mathematics education departments. Those students with stellar academic records are more likely to pursue graduate work in the discipline. Unfortunately, since many undergraduate mathematics majors perform poorly in their undergraduate mathematics course work or leave their departments without receiving their degrees, there will be few future mathematicians continuing in the pipeline. Thus, there will be few African- American mathematicians and mathematics educators in our nation's universities (Anderson, 1990).

Rationale

Much of the research concerning minority participation in mathematics investigates the underlying factors affecting students' lack of success and persistence in SEM related disciplines. However, very few research studies investigate those African-American students who excel in SEM disciples and pursue degrees in SEM majors. Even scarcer are studies that investigate the experiences of high achieving African-Americans who pursue majors in mathematics specifically.

Historically, researchers link SEM disciplines together because they require extensive mathematics background, and these students are required to take mathematics

courses beyond calculus for their majors (Oakes, 1990). Also, these disciplines have high attrition rates (Seymour & Hewitt 1997), and many minority students are not prepared to take on the academic rigor of these disciplines (Stiff & Harvey, 1988). Although these majors are linked and share common characteristics, in this study I am investigating mathematics majors. I believe that mathematics majors have challenges and issues that are unique because of the nature of the discipline.

Unlike other SEM disciplines, mathematics requires abstract thinking. In upper level mathematics courses, students are required to use extensive deductive reasoning and known results to generate proofs of ideas that may or may not have an experimental basis. Unlike the sciences, where there is an emphasis on exploration and experimentation **(**American Association for the Advancement of Science, 1990), traditional mathematics majors are required to understand very abstract concepts and to be able to use deductive logic alone to justify claims. This, many believe, makes mathematics particularly difficult for African-American students, who find this abstract theory-based learning inconsistent with their experience and learning styles (Ladson-Billings, 1994; Tate, 1997). This inconsistency translates to students' decision to leave mathematics majors once they enter their upper level courses, where the mathematics content becomes more abstract. African-American mathematics majors, who experience some of the same challenges as other SEM majors, are more at risk due to the abstract, logic driven nature of mathematics. Hence, understanding the experiences of African-American students who do well despite these challenges can provide valuable insight for the mathematics community. Furthermore, since the population of African-American

high achieving mathematics majors is so small, I believe these students require direct investigation.

In recent years, there has been a growing interest in understanding student success in mathematics; however, many of these studies have been quantitative (Hall, & Post-Krammer, 1987; Hill, Pettus & Hedin, 1990; King, 1995; Mathews, 1984; Tate, 1997) and do not include students' perspectives. Few studies have been conducted that examine the experiences of African-American students who remain in the mathematics pipeline through undergraduate school (Bailey, 1990; Cooper, 2000; Figgers, 1997; Moody, 1997; 2000; Williams, 2003). Relatively absent from the literature are students' perceptions of their family, educational, communal and personal experiences, specifically those experiences that contribute to their persistence and success in mathematics.

More specifically, the research reveals very little about African- American students who excel in mathematics. The scarcity of research on African-American success in mathematics creates the perception that there are no successful African-American students in the major. Hence, we understand very little about the experiences of these high achieving mathematics students, and we lack insight into what has "worked" in the homes, mathematics classrooms, and communities of these African-American students to produce future mathematics scholars. This is a travesty considering that many initiatives developed by the National Council of Teachers of Mathematics (NCTM), policy makers and community advocates encourage "high achievement in mathematics for all students (Mathematical Sciences Education Board, 1990; NCTM, 1989; 2000)." Inadvertently, the voices of those who have been successful are left out of the literature. After all, they are examples of the best and the brightest in the mathematics

pipeline and should be included in any meaningful dialogue on achievement and success in the discipline.

Purpose of the Study

The purpose of this study was to identify and understand the factors that influence high-achieving African American mathematics majors to persist and succeed in mathematics. In this study, persistence is defined as continuing to remain in the mathematics pipeline through college, while success is defined as students who are performing well as defined by their college performance in mathematics. This study examined the students' family, educational, communal and personal experiences and their perceived impact on their success. In light of the current focus on under representation, underachievement and lack of persistence of many African American students in mathematics in the literature, this study sought to understand those African-American students who have succeeded despite the odds. The study sought to give voice to students who have been successful in mathematics. Ultimately, the understandings we gain from these "elite" students can be used to inform high school and college mathematicians and mathematics educators of what experiences can be cultivated to impact future scholars and to gain a more complete understanding of the contexts in which these students successfully navigated the mathematics pipeline.

Research Questions

The major research question guiding this study is: What perceived factors contribute to high achieving African-American junior and senior mathematics majors' decision to

persist and succeed in mathematics through college? This study also seeks to answer the following sub questions:

1. In what ways do African- American high achievers perceive the role of the family, educational institutions, and the community in their success and persistence in mathematics?
3. How do they perceive their own role in their success and persistence in mathematics?

Research Design

To address my research questions, I conducted a case study of eight high achieving African- American junior and senior mathematics majors. Each student in this study was viewed as a unique case, and themes that were found throughout each case was compiled, analyzed and reported. Because I wanted to understand the family, educational, communal and personal factors that influence high achievers' success and persistence in mathematics, I used purposeful sampling to select students for this study. Students were selected from one historically black university (HBCU) and two predominately white universities (PWU) on the east coast of the United States. Guided by social and cultural factors identified in mathematics education literature and elements of the college success and retention literature on African-American students, I sought to understand these students' experiences and the perceived impact of their experiences on their success and persistence in mathematics. Interview data was collected and analyzed over a six-month period. I used coding strategies discussed in Miles and Hubberman (1994) and Strauss and Corbin (1998). In addition, I used the NiVivo qualitative software to assist in data organization, analysis and retrieval. These strategies included beginning with a start list

of codes developed from my conceptual framework. These codes were adjusted, expanded and refined as data was collected and analyzed. Open and axial coding methods were utilized to develop pattern codes. These pattern codes served as the basis of themes and assertions. Throughout the process, several credibility and trustworthy warrants were employed to assure the quality of the results.

Conceptual Framework

Borrowing elements of social, cultural and personal factors identified in mathematics education research and elements of the college persistence literature on African-American, I used these theories as a framework to interpret and analyze these students' experiences. These ideological perspectives were critical in unpacking the factors affecting this population of students.

A key component of this research was to understand the perceived social, cultural and personal factors that impact this elite population's success and persistence in mathematics through college. Therefore, I utilized multiple frameworks in order to understand both of these aspects of these students' experiences. I believed that no single framework was sufficient to this understanding; hence, I adopted elements of several theories that will serve as my lens to understand the experiences of this population.

Several studies of achievement, particularly mathematics achievement, reveal that society and culture play a significant role in student success (Cooper, 2000; Fisher 2000; Ladson-Billings 1994; 1995; Moody 2000; Martin, 2000; Tate, 1995). A growing body of research in mathematics education highlights the role of students' society and culture on their performance and persistence in mathematics. Within this broad research, several social and cultural characteristics have been identified as having an impact on African-

American students' success and persistence in mathematics. These factors include caring teachers and school personnel (Figgers, 1997; Moody, 1998; 2001), the presence of role models and mentors (Cooper, 2000; Hill, Pettus & Hedin, 1990), parental involvement and support (Catsambis, 1994; Figgers, 1997; Ma, 1999; Martin, 2000) and the desire to fulfill a need in the community (Cooper, 2000). These factors were also revealed in an earlier pilot study I conducted. In this study, I will use these identified characteristics to help me understand the students' social and cultural experiences and their perceived impact on success.

I also sought to understand the students' own role in their success and persistence in mathematics through college. Guided by my own experiences, results from the pilot study and the research literature, I have identified several personal characteristics that I believe are critical to understanding the students' perceived role in their success and persistence in mathematics. The available research that has been done on African-American students' success and persistence in mathematics reveal several personal characteristics that influence students' persistence in mathematics. These characteristics include self-efficacy (Bandura, 1986; Hackett, 1981; King, 1995; Pajares, 1996), positive attitudes about mathematics (Hill and Pentus, 1990), the perceived usefulness of mathematics to their future goals (Cooper, 2000), and positive mathematic self-concept/ identity (Cookely, 2000; Fisher, 2000; Martin, 200; Pajares, 1996). I used these identified factors as a way to understand how these students perceive their own role in their persistence and success in mathematics. I wanted to see if these factors contribute to this elite population's achievement and persistence in similar or different ways than other populations of students.

In addition to understanding the experiences that influence African-American students' success in mathematics, I was interested in examining their college experiences and the influence of these experiences on their persistence and their decision to major in mathematics. Hence, I borrowed elements from the college persistence and success literature in higher education to help me understand these students' college experiences and their perceived impact on their college persistence. This literature suggests that the nature of students' cultural and social interactions in college has a tremendous impact on students' achievement and persistence in college. Particularly, the degree to which African-American students are integrated into the social and academic climate of the university is a huge indicator of retention (Astin, 1982; Fries-Britt, 1998; Tinto, 1987; 1993).

The social and cultural experiences that have been identified as having impact on minority students' retention are the presence of role models (Martin & William-Dixon, 1991; Mirande, 1985;), peer support (Fries-Britt, 2000; Fries-Britt & Turner, 2002; Parcella & Terenzini, 1979), family support and encouragement (Astin, 1982; Hrabowski et. al 1998; 2000; Raymond, Roads, and Raymond, 1980;), and the availability of financial resources (Beal & Noel, 1980; Martin, 1985). In addition, several psychological factors have also been identified as having influence over some highly successful college students' decision to persist in college including academic self-concept, values, beliefs and racial identity (Cooley, Cornell, and Lee, 1991), and resiliency (Getz, 2000; Goodwin, 2000).

My Values and Assumptions

As an African- American woman who has been successful in mathematics, I brought several biases and values that impacted the nature of this study. Growing up in a predominately African-American neighborhood and attending an all African-American high school, there were few students who expressed an interest in mathematics, nor were there many who achieved in the discipline. I was one of two students who took calculus in high school, since there were no students eligible to take the course. In fact, most of my peers had an overall lack of interest in the subject and felt that it was a waste of time and energy.

After graduating valedictorian of my high school class, I went to undergraduate school at a historically black college where I pursued a degree in mathematics. Fellow students marveled at the major I had chosen, and as my peers in high school expressed, they also thought I was either extremely smart or crazy for remaining in a major that was "hard" and did not guarantee hefty financial rewards. Despite the challenges I faced in undergraduate school, I disagreed with my peers and believed that studying mathematics was important and essential in my development, and I wondered if there were others who shared my success and persistence in the discipline. I was one of seven African-American students who graduated with a degree in mathematics, and I pursued graduate study in mathematics with a desire to encourage other African-American students to succeed and persist in mathematics. Consequently, I became interested in understanding the experiences of other African-American students who choose to major in mathematics,

because I believe that to understand success it is important to study success-which is the focus of this proposed research study.

Significance of the Study

As mathematics educators embrace the need for mathematics reform (NCTM 2000) designed to encourage "opportunities for all students" and "success for all students," it is imperative that student experiences and voices be included in the literature surrounding mathematics success. Understanding "what works" in mathematics education would be incomplete without studies that focus on the student's experiences and perspectives. The voices and experiences of successful African-American mathematics students, which have traditionally been underrepresented in the literature in mathematics education, must be investigated. Understanding the experiences of these high achieving students can provide valuable insight for mathematics educators and others interested in the persistence and success of African-Americans in mathematics. .

This study's findings can provide valuable information to parents, schools, educators, community leaders, researchers, and policy makers by providing insight into what can be done to cultivate future mathematicians and mathematics educators. By examining the experiences of these successful students, we can begin to reflect on what classroom practices, community experiences, and family experiences have the greatest impact on African- American students' success in mathematics. From these stories, the mathematics community can more effectively prepare future African-American mathematicians and mathematics educators to succeed and persist. This distinct

population can help us understand the factors that lead to success and resilience in a discipline where the norm for this group is failure and despair.

Definition of Key Terms

In order to clarify the ideas presented in this research, several important terms key to this research must be defined.

1. Mathematics major- a student who has declared and is currently pursing an undergraduate degree in mathematics or secondary mathematics education
2. Persistence- students' decision to continue a particular course of study through college.
4. High Achieving - students identified as honor students and/or having a cumulative GPA of 3.0 or better in all academic coursework, major GPA 3.0 or better.
5. African- American- defined in this study as students who are of African decent born and raised in America. I am intentionally not including students of African decent who were born and/or raised in other parts of the world. I am particularly interested in the experiences of students who are considered involuntary immigrants (Brown, 2000; Goodwin 2002; Ogbu 1991) who are sole products of the American school system.
6. Junior or senior student- a student who has earned a minimum of 60 college credits with a GPA of 3.0 or better. The student must have complete at least two semesters of calculus, be enrolled or previously enrolled in a theory-based mathematics course, and be currently enrolled in mathematics coursework that is leading to an undergraduate degree in mathematics.

7. Theory-based mathematics course- a mathematics course that requires deductive reasoning and extensive proof writing. Examples of these courses are Advanced Calculus, Abstract Algebra, and Topology.
8. A high achieving African-American mathematics major – is a junior or senior, of American decent, has a cumulative GPA of 3.0 or higher on a 4.0 scale, completed college calculus, and is enrolled or previously enrolled in at least one theory-based mathematics course.

CHAPTER II:

REVIEW OF RELEVANT LITERATURE

Overview

As we seek to understand the experiences that impact high achieving African-American math majors' decision to excel and persist in mathematics, it is important to provide a context by examining the literature that informs this study. Because of the nature and scope of the research questions, several bodies of research were investigated that informed the theoretical framework for this study, and this chapter is a synthesis of that research. This literature review is divided into four main sections: African-American students' achievement in the mathematics pipeline, African-Americans students' persistence in higher education, research on African American high achievers in higher education and concludes with research concerning African-American students' success in college mathematics.

The chapter begins with a discussion of African-Americans in mathematics and the factors that have been shown to influence their success and persistence in mathematics. Next, I discuss relevant studies that highlight the social, cultural, educational, family and personal experiences that have been found to impact African-American students' success and persistence in mathematics The second section of this literature review begins with a broad discussion of college retention literature specifically related to African-Americans and the factors that impact their persistence in college. Next, there is a discussion of studies that focus on African-American high achievers in college and what scholars have found about their experiences in higher education. Finally, this section ends with an analysis of studies that examine successful African-

Americans in mathematics and the factors that have been shown to impact their success in college mathematics courses. Throughout this literature review, I will highlight pertinent studies that inform this research and the gaps in the research that this study sought to address.

African-American Students' Achievement in the Mathematics

Much of the research regarding African-American students in the mathematics pipeline is laden with stories of underachievement, low-performance and early attrition (Anderson, 1990; Ladson-Billings 1994; Oakes, 1990; Secada, 1992). Several explanations have been given to explain why African-Americans fail to pursue and succeed in mathematics including: lack of interests in the subject (Berryman 1983; Hill & Pettus, 1990), low socioeconomic status (Patterson, 1997), negative teacher attitudes, culturally incongruent curriculum (Berry, 2003; Landson-Billings, 1994; Martin, 2000; Tate, 1995), and a history of poor achievement (Anderson, 1990: Berry, 2003; Oakes, 1990; Schoenfeld, 1992). Other studies reveal that minority students are turned off by the culture and attitude of the mathematics community and lack confidence in their mathematics ability (Powell, 1990). There is a growing body of research that examines successful African-American students and their persistence in the discipline (Cooper, 2000; Moody, 1998; 2000; 2001). However, there is scant research on the elite group of students who are high achieving mathematics majors.

Social and Cultural Factors

Research focusing on the achievement of African-Americans in mathematics suggests that society and culture play a significant role in these students' success and persistence in mathematics **(**Figgers, 1997; Fisher, 2000; Hill, Pettus & Hiden, 1990**)**.

Understanding the society and culture that these high-achieving students are exposed to can provide major insight into their mathematics achievement. In her dissertation, Vanessa Figgers (1997) examined mathematics achievement and career choices of African- American women in the mathematics and mathematics education. The subjects for her case study were three African- American women who pursued study and careers in mathematics and mathematics education. She found that teacher and parental influence, nurturing home environments, and educational and job opportunities were major influences on the career decisions of her subjects. In addition, the participants reported that teachers, siblings, community and college professors also influenced their decisions to major in and persist in mathematics.

Given that the participants of Figgers (1997) research were successful African American women in mathematics, the participants in this study may cite similar influences. However, the participants in the Figgers study had already completed their degrees and were at a different place in their academic and professional careers. Hence, the results of this study will provide greater insight into the experiences of undergraduate mathematics students. This can help inform the literature of what factors impact high achieving undergraduates' success and persistence in mathematics.

Research has been devoted to understanding the impact of multiculturalism and culturally compatible pedagogy in mathematics (Brown, 2000; Ladson-Billings, 1995; Tate, 1995). Much of this research suggests that when the pedagogical styles used in mathematics classrooms is compatible with the learning styles and every day lives of African American students, these students thrive. Ladson-Billings, 1994, 1995; 1997 describes the educational practices of two teachers who had been successful with

African-American students. The teachers in these studies employed teaching strategies that the researcher refers to as culturally relevant. These strategies positively impacted African-American student success in mathematics. Characteristic of this type of teaching strategy include demonstrating care for the students, holding high expectations for all students, connecting the curriculum with the students' lives and their community, and fostering a family-like environment in the classroom. Since the students in this study are successful mathematics majors, I suspect that they may share experiences with teachers who share some of the characteristics identified in the Landson-Billings studies.

Importance of Role Models

When practicing scientists mentor minorities, there is an increase in motivation and identification with the academic discipline. Researchers suggest that African-Americans tend to select occupations in which they have had contact with successful role models. They also note that these students tend to select careers in fields where they perceive opportunities for employment; hence, they are more likely to pursue careers in the social sciences and the humanities (Hall and Post-Krammar 1997; Murphy, D. & Sullivan, K, 1996).

In a series of important studies conducted by Hill, Pettus & Hedin 1990, The Science Career Predictor Scale was administered to a sample of 522 middle and high school students and students from a local historically black college. The results from the middle and high school sample showed that personal acquaintance with a mathematician or scientist was the most influential variable for students choosing science related careers. Variables shown to be significant influences on career choice in the sample of Black female and male students (both high school and college aged) were interest in the subject

and participation in science related activities. Also, the results of this study strongly suggest that personal acquaintance with a scientist is a major contributing factor to pursuing a career in the sciences. Since this was a quantitative study, there was no discussion of the scope and nature of the relationships with scientist that made the most differences on these students' career choice, nor was it clear that researchers included mathematics majors. This research is designed to provide insight on the kinds of interactions that impact students' persistence in mathematics, and the results from this research which indicated the impact of role models informed this study.

A recent article based on interviews and questionnaires from Black Ph.D. students from the University of Maryland (Cooper, 2000) reveals varied reasons for choosing to pursue an advanced degree in mathematics. Some of the reasons ascertained were: to gain understanding of mathematics and to gain respect, the love of mathematics, an interest in mathematics research, to fulfill a need for more non-White professors, and to meet others' expectations. Throughout Cooper's article, he reported that many students felt that the mentoring they received from their mathematics professors as undergraduates and graduates was instrumental in their decision to continue in the mathematics pipeline.

These studies reveal that more role models and the cultivation of an interest in mathematics and science can have a significant effect on African- American students' decisions to pursue undergraduate degrees in the sciences. More research must be done on those African-Americans who are successful in these careers. The above research indicates that many school related variables have some effect on African-American students' decision to remain in mathematics pipeline in college. Although these studies did not look specifically at high achieving African-American students, it is reasonable to

expect similar results with the population to be investigated in this study. More research needs to be done that takes a longitudinal look at successful African-American students' decisions to persistent in mathematics over time. In addition, In-depth case studies that examine the interaction of a variety of variables on African-American students' success will also help clarify how the interaction of many variables affects these students' achievement and persistence.

Parental Influences

Numerous research studies reveal that parental support and involvement plays a critical role in their children's' success in school mathematics (Catsambis, 1994; Figgers, 1997; Hrabowski, F, et al 2002; 1998; Ma, 1999; Mathews, 1990; Williams, 2003). Moody (2000) interviewed successful African-American college students in mathematics and found that parental support was vital to their success with school mathematics. The participants identified supportive, caring, and nurturing parents as vital to their success in mathematics. In their study of academically successful African-American males and females in the Meyerhoff Scholars program, a program designed to increase the numbers of research scientist and engineers, Hrabowski, et al (1998; 2002) examined the influences of the family, particularly the students' mothers and fathers, on African-American male (1998) and female (2002) students' academic success in mathematics and science. In both studies, the researchers found six essential strategies that promoted the academic success of their students: child focused love, strong limit setting and discipline, high expectations, open and honest communications, full use of community resources, and strong ethnic and gender identity. Many of the student and parent stories highlighted

how these factors impacted academic success despite perceived academic shortcomings. Students in both studies resounded that their parents were instrumental in their decision to do well in school and achieve in science and mathematics. Since the research team's primary focus was on the parent's role in their children's success, it is unclear what role, if any, extended family and community members played in the students' success in mathematics and science.

In this study, I found it necessary to examine influences of students' extended family and communities in order to get a more complete picture of factors that impact African-American students' success. In the Hrabowski study, it was not clear that any of the participants were mathematics majors. It will also be useful to see if parental influence impacted mathematics major in similar ways.

Psychological and Affective Variables and Mathematics Achievement

Psychological factors such as, self- efficacy and self concept, and affective variables, such as attitudes and beliefs, have been shown to play a central role in mathematics achievement (Bandura, 1982; King, 1995; McLeod, 1992; Pajeres, 1996; Schreiber, 2002). For example, Ma (1997) found that students' attitude about mathematics and their belief in the importance and usefulness of mathematics were significantly associated with achievement in mathematics. Similar findings were also found in a subsequent study (Ma, 1999) in which the researcher, using survival analysis and multilevel modeling, showed that attitude toward mathematics was the most important factor in mathematics participation. This is particularly true in the later grades of high school when dramatic drops in participation occur (Ma, 1999, p. 68).

Other researchers have also argue that affective factors such as beliefs, attitudes, and emotional reactions to mathematics affect students' performance on teacher constructed and standardized tests (Hart, 1989) and successful class performance (Martin, 2000). These affective variables influence an individual's decision to take higher mathematics courses (Hill & Penttus, 1990), excel in mathematics coursework (Moody, 1990) and continue in the mathematics pipeline through college. For example, Scheriber (2002), using data from the Third International Mathematics and Science Study (TIMSS), studied 1,839 U. S. students from 162 schools who were designated as having advanced mathematics skills. Using a two-level hierarchical linear model with student-level variables (gender, parent education, attitudes) at the first level and school related variables (school size and resources); the researcher examined the relationships among mathematics achievement and student institutional (school) factors. He found that students who took advanced mathematics courses had high levels of self-efficacy and attributed their success to both high ability and hard work. These students believed that both of these factors where crucial to their success in advanced mathematics. The results of his study also indicate a relationship between parent education and positive attitudes about mathematics on students' mathematical achievement. Given the population under investigation for this study, similar factors may also be found in to impact the students in this study.

Minority Student Retention

Since this study focuses on high-achieving African-American college students, I found it important to investigate literature on African-American college student retention. Elements of this research are used as a lens to understand this population's persistence in

the mathematics pipeline through college. Access and perseverance in higher education is important in the training and development of our future mathematicians. Hence, it is important to understand those factors that contribute to students' persistence in college in general and specifically in mathematics. Many researchers have documented the issues related to African-American students in higher education and the factors that affect their decisions to persist in college. This section highlights major research on the various factors that affect minority students, particularly African-American students' attrition in American colleges and universities and gives a brief overview of several programs that have been designed to facilitate successful retention. When appropriate, specific studies that address African–American students in the science and mathematics pipeline will be highlighted. This literature review is by no means exhaustive; however, it can give the reader insight into what scholars have found to be some of the influences on black student retention and attrition, and what has helped African-Americans and other minorities stay in the educational pipeline through college, specifically the mathematics pipeline.

Four main themes or categories began to emerge from review of research on factors that influence African-American students' success and persistence in higher education. Social/cultural variables, psychological/self-concept factors, academic factors and financial factors were variables cited most often as having an impact on minority student retention (Astin, 1982, Christoffel, 1986; McJamerson, McConnel & James, 1989). As with most educational research, it is difficult to isolate these variables and therefore determine the extent to each of these components impact retention. However,

there is considerable evidence to suggest that these factors have contributed to the substandard representation of African-Americans in degree completion rates.

Social and Cultural Factors and Retention of African American Students in Higher Education

Society and culture have a tremendous effect on people lives from birth to death; hence it is not surprising that these factors have an effect on students, particularly black students' decision to persevere in college. Many studies have identified cultural and social interactions as primary influences on minority student retention. Often, African-American students experience a school institution that is unsupportive of their needs. They, therefore, feel alienated and isolated from the university's social and academic culture (Astin, 1984; Lunneburg & Lunneburg, 1986; Tracey & Sedlacek, 1985). This theme of alienation particularly applies to students attending predominately white colleges and universities (PWCU's). In a study conducted by Lunneburg and Lunneburg (1986), minority students at PWCU's were given a questionnaire that was designed to get at what was affecting them at the university. Social isolation was the most common complaint cited by minority students. Astin (1982) also documents how the lack of belonging affects the retention rates of minority students.

America's history of discrimination against African-Americans is well documented. African-Americans have historically been denied access to social and cultural institutions, including colleges and universities. Even with greater access to higher education, discriminatory and unfair practices remain. These practices have had and continue to have a negative impact on the educational experiences and retention of

African-American students. In his doctoral dissertation, Copeland (1976) surveyed African-American students and dropouts at PWCU's. Most African-American students reported bad experiences at the colleges and felt that discrimination caused many students to drop out of school.

In addition to the social and cultural disconnect that black students experienced at PWCU's, African-American students also report that the college environment does not reflect their culture and is not supportive of their heritage, traditions, and values. According to Tinto (1987; 1993) one of the pioneer researchers in the area of retention, academic and social integration is necessary in order for a student to continue through graduation. Academic integration refers to academic success, while social integration refers to personal/social success, which includes feeling connected with peers, staff/faculty, and the overall campus social life (Pounce, 1988). In order for social integration to occur, it is argued that the student must assimilate on some level to the values and goals of the institution, which are oftentimes diametrically opposed to the values of minority students' parent cultures. Hence integration appears to be difficult for many African-American students, since by "integrating" they often must assimilate into the dominant culture, disassociate themselves from their communities, and reject their cultural identities (Tracey, & Sedlacek, 1985), which seems to be unacceptable for many students.

The lack of multiculturalism in higher education, the devaluing of the contributions of other cultures and the outright omission of African-American students' voices in the academic discourse are sources of contention for many of these students.

This culturally limited pedagogy often contributes to isolation and subsequent non-persistence in higher education. Armstrong-West & de le Teja write:

> American college and university curricula tend to be monocultural: most of the courses are taught from a western European perspective. The history and contributions of Europeans and their descendents are emphasized. … Expanding this curriculum to include the contributions of all racial and ethnic origins is necessary to benefit all students, not just minority students (p.25)

A study by McJamerson, McConnell, and James (1989) was designed to identify the participation trends for different cohorts of students, to develop race-gender profiles of persisting and non persisting undergraduates, and to assess the perceptions of these students. The researchers found that Black non-persisters expressed dissatisfaction with the level of awareness and acceptance of their cultural issues and problems, inadequate opportunities to participate in culturally relevant social and educational activities, and inadequate institutional support for Black student activities. These issues were found to have an impact on their attrition. By expanding the curriculum to include the voices and perspectives of minority students, universities can decrease their minority students' feelings of isolation and marginality and increase their success. Other authors have reported similar findings (Fleming, 1988; Portes & Wilson, 1976).

According to researchers, the role of the family in the educational process plays a significant part in retention. Minority cultures tend to place high value on the role of family compared to the majority culture (Armstrong-West & De la Teja 1988: Perna, 2000; Raymond & Roads, 1980; Perna, 2000), and accordingly, lack of family support emerged as one of the factors affecting their retention. According to Raymond, Roads, and Raymond (1980), African-Americans and Hispanic –Americans place a greater emphasis on the importance of family relationships than their white counterparts do. To

succeed in college, students must often abandon their family ties and reject their cultural identities (Tinto, 1993). Hence the research suggests that this forced separation can have an adverse affect on student retention. Tracey and Sedlacek (1985) examined the non-cognitive variables that contributed to the academic success of African-American students and found that family support had a tremendous impact on the persistence rates for black students, particularly during the first year. This is consistent with the findings of other researchers (Astin 1982; Fleming 1985; Porter, 1974).

Contributing to this unsupportive and isolating environment, African- American students often have very little access to role models throughout their educational careers, and this continues through college. Ample research has been conducted on the effect of role models and mentors for students' success and education (Moyer, et. al, 1978; Martin & Williams-Dixon, 1991). If these role models are not present, it could have an adverse effect on student persistence and performance. Moyer et.al (1978) conducted a study on the retention efforts employed by Stark Technical College designed to increase the number of minority students in their technical programs. The college created a task force charged with implementing several programs to meet their retention goals, including a role model recruitment program. They found that the role model program was highly successful in increasing minority recruitment. Similarly, Martin & Williams-Dixon, (1991) conducted a study to examine Black students' cognitive processes of collegiate experiences at a large predominantly white southern university. Students were given questionnaires to understand their interpretation of their experiences, and to identify experiences that affected their decisions to persist or withdraw. They found, among other things, that black faculty served as positive feedback mechanisms for the black students.

Their presence enabled the students to feel secure on predominantly white campuses, and "black faculty models can alter negative thoughts so that black students can achieve their postsecondary goals (p. 14)"

Psychological Factors

An individual's self-concept and identity are the backbone of a successful person, and consequently a successful student. What a student brings to a college or university influences his/her goals and commitments. These variables (pre-entry attributes, goals and commitments) affect one's institutional experiences, and therefore influence his or her departure decision (Tinto, 1987; 1993). Hence, psychological affective variables such as self-concept, values, attitudes, motivation, beliefs, and personal satisfaction with oneself and college play a critical role in the retention of all students, and more importantly for African-American students.

African-American students are often marginalized in educational institutions and are stereotyped as less capable and academically inferior than white students (Gamson, Peterson & Blackburn, 1980; Loo and Rolison, 1986). Also, their performances on standardized test are not as high as their white counterparts (Sherman, Giles & Williams-Green, 1994). These experiences often produce students who are "academically beat down," and therefore have a low concept of themselves and their academic abilities. As Armstrong-West and H.de la Teja (1988) observe*:*

> An individual's idea of who she or he is –the self concept- contributes significantly to how the individual responds to society's institutions. The extent to which a person's self-concept is confirmed or rejected by others is crucial to the person's development and to social and academic integration (p 36).

"Academic self- concept can be broadly considered to be how a student views his or her academic ability when compared to other students (Cokely, 2000, p. 149)." Academic self concept has been positively linked to student success in college (Reynolds, 1998; Gerardi, 1990), and there is a growing body of research that examines the role of academic self-concept and academic achievement specifically related to African-American college students (Cokely, 2000; Heath, 1998). Cokely (2000) examined the academic self concept is a sample of 206 African-American college students attending HBCU's and PWCU's. He found that there was no significant difference between the academic self concepts of the students attending HBCU's and PWCU's. However, the results of his study reveal that students with higher GPA's had higher academic self concepts. This implies that African- American students' academic self concept has a positive relationship on their achievement in college. Hence, high academic self concept may be an important factor shaping the success of the high achieving African-American students investigated in this study.

Researchers have found that blacks on predominantly white campuses lack psychological support systems that could help foster their retention (Martin, O. & Williams-Dixon, R. 1991; Tracey & Sedlacek, 1985). When African-American students are afforded these support structures, they are more likely to persist in college (Armstrong-West & De la Teja, 1988; Flemming, 1984; Allen, 1998). Several research studies have been done that investigated black students' experiences at PWCU's, and researchers have found that colleges and universities tend to neglect and ignore the psychological needs of minority students. In a study conducted by Tracey & Sedlack

(1985) also found that lack of psychological support systems in universities contribute to student attrition.

In several studies, feeling of isolation and alienation was one of the most often cited reasons why African-American students did not persist in higher education institutions, particularly PWCU's (Allen, Bobo& Fleuranges 1984; Stewart & Van, 1986; Tracey & Sedlack, 1985; Smith, 1981). Loo & Rolison (1988) found that black students find it difficult to become members of supportive communities at most predominantly white universities, and they are more likely to experience feelings of isolation and marginality. In a study that examined the social and academic environments which black students experience on PWCU's, Smith (1981) identified alienation and loneliness as central causes to the high attrition rates among black students. Martin (1991) also noted that black students found their college environments unsupportive of them, and perceived blacks at predominantly black colleges and universities to have a more supportive environment than they did.

There is a solid body of literature that specifically addresses the behaviors of resilient African American youth as "those individuals exposed to high stress, but [who] show no signs of Impairment (Steward, R, et. al, 1998)." Resilience is a characteristic that has been linked to African-American college students' ability to remain steadfast in colleges and universities that may or may not support their academic and/or social development (Getz, 2000; Goodwin, 2000). Blocker and Copeland (1994) found that resilient youth tend to have an internal locus of control, take an active orientation to life, seek out others for support, be less likely to go along with the crowd, are involved in a greater number of positive activities, spend more hours on homework, and spend fewer

hours alone. The Blocker and Copeland study examined youth that they considered "high stressed," and did not look specifically at African American youth. However, other researchers found similar experiences with African-American youth who come from environments of high stress, poverty and academic inequities (Rutter, 1990). Despite these challenging life experiences, these students have been shown to succeed in higher education. "Resilient students are often self-efficacious: they believe in themselves and their ability to succeed (Getz, 2000, p 459)." This attribute, researchers argue, is a key ingredient to African-American students' success in college.

Getz (2000) explored how students viewed their own sense of resiliency and how this impacted their self-efficacy and success in higher education. Her studies revealed that the students believed that the difficult experiences they encountered made them stronger, and they were hopeful about being in college. However, her findings also revealed that many of the students were disappointed and frustrated because they did not always feel that the institution either understood or embraced them. They relied heavily on their strengths as resilient students to master the college experience (Getz, 2000).

Highly related to self –concept is racial identity. Racial identity is a component of self-concept, and the value that a person places on his or her racial identity contributes to his or her self worth (Armstrong-West and H.de la Teja, 1988). Many researchers have found that universities do not recognize or value cultural differences and have failed to examine the importance of promoting racial pride as a means to retain students. As Goodman (1972) asserts, an individual's idea of who he or she is contributes to how the person responds to social institutions, and racial identity is an important component of ones self concept. When universities fail to value this identity, minorities, including

African-American students, are more likely to withdraw from the institution (Rice, 1989).

Thus far we have examined social and cultural facts as well as psychological climate. Each of these has an impact on African-American students' persistence. In addition to these issues, there are several academic and financial factors that have been found to impact these students' persistence in higher education.

Academic Factors

Contrary to the popular notion that minority students drop out mainly because they cannot "cut the academic mustard," many withdraw for non-academic reasons (McJamerson, McConnell, and James 1987). Nevertheless, academic difficulties have been shown to affect black student attrition, even with students who have commendable academic records from high school. These difficulties include: academic under-preparedness/ poor quality of previous education, negative faculty expectations, negative interactions with faculty members and peers, and lack of educational resources and support (Oakes, 1990**)**.

It seems that African-American students are more likely than white students to experience academic problems, which can significantly impact retention (Donovan, 1984; Thomas et al, 1994). Many African-American students trained in substandard, under-resourced schools are entering college. These under-prepared students are at risk even if they performed well in their high schools. They are unable to compete academically with their white counterparts who hail from economically prosperous schools that are more academically demanding (Astin, 1985; Thomas et al, 1994). Noel and Levitz (1982) offer three definitions for identifying academically under prepared students: 1) students who

need skill development; 2) students who do not meet regular admission standards such as low SAT scores, or GPA; 3) students who have placement test scores below the cut off point to be admitted to regular college classes. Not surprising many minority students, particularly those from low socio-economic households fall into one or more of these categories, and consequently these students have higher attrition rates.

Much educational research has highlighted the role that teacher expectations have on student learning in grades k-12, and it appears that this correlation exists at the college level as well. The relationship between faculty expectations and student's intellectual development has been investigated by several researchers (Rendon, 1989; Trujillo, 1986; Willie & McCord, 1972). Some studies have found that interactions between black students and predominately White faculty adversely affect their retention (Holliday, 1985; Howard & Hammond, 1985). Gamson, Peterson and Blackburn (1980) explain that white faculty members are often anxious about teaching African-American students, which may be caused by their misperceptions about the students' academic capabilities, and the prevailing attitude of many faculty members is that African-American students do not measure up intellectually (Howard & Hammond, 1985).

Negative expectations of minority students by white faculty has lead to negative interactions between these students and the majority faculty charged with serving them. Many researchers cite the negative treatment that African-American students receive from majority White faculty members (Burrell, 1981; Parcella & Terenzini, 1979; Trujillo, 1986) as a major issue facing minority students. Martin & Williams-Dixon (1991) research revealed that the academic setting was the dominant source that influenced black students' thought processes. They explain that what happens in these

(academic) settings with professors and peers and how these experiences are interpreted has a tremendous impact on black students' evaluation of themselves and the environment. Based on these experiences, black students arrive at the decision to persist or withdraw from that college setting (p.12).

Other studies have arrived at similar conclusions (Burrell, 1980; Fleming, 1985; Parcarella & Terenzini, 1978). Chickering (1969) argues that after relationships with peers and peer cultures, relationships with faculty are next in importance. These student faculty interactions can have a positive influence on academic integration and intellectual development, and the quality of these interactions plays a significant role in a student's academic growth and persistence (Duby & Iverson, 1983). Nettles (1991) found that students' satisfaction with faculty relationships, their feelings that the faculty of the university is sensitive to their interests, and their satisfaction with the quality of instructors are essential elements to their decision to stay or leave school. Hence the quality of faculty student interactions is important for retaining African-American students in education.

Given the above research documenting some of the challenges that African-American students face at predominantly white institutions, it could be expected that minority students may need special academic and social resources to assist them in maximizing their success at these schools. Unfortunately many African-American students find that these resources are not there or are incompatible with their academic and social experience. After beginning their academic programs at these schools, they often find themselves in environments that are unable or unwilling to provide them with the academic resources that are necessary for their success. Boyd (1979) asserts that most

African-American students feel that they can succeed in college with a small amount of academic assistance, and the colleges should provide academic support to those who need it.

Financial Factors

There is little agreement among researchers on the role of financial difficulties in college attrition; however, some have found that financial issues are one of the most frequently cited reasons students give for leaving college (Beal & Noel, 1980; Martin, 1985). Low-income students are often the hardest hit by the financial strains of college, and since many minority students fall into the low-income category, they are most affected by financial issues. Decreased availability of financial aid, increased emphasis on loans to finance college, and skyrocketing tuition rates are said to have an effect on low admission and retention rates of Black and other minority students.

Porter (1990) explained that the availability of financial aid, particularly in the form of grants, had a significant effect on student persistence in college. In fact, he found that 90 percent of students who received grants continued through their sophomore year; whereas, the persistence rates of those not receiving grants was about 75 percent. When examining the numbers for black students, he found that about 60 percent of black students who did not receive a grant dropped out after the first year (Porter, 1990). Boyd (1974), interviewed African-American students at 40 colleges and universities across the United States and offered several recommendations based on the responses to the interviews. He suggested that financial aid for Black students be maintained at their current levels or be increased. He found that finances were a major concern for Black students, and they often worried about having enough money to complete their college

education. These concerns, he argued, hindered their academic performance impinged on the intellectual and psychological growth of the students (Boyd, 1974).

Many researchers agree with Boyd's findings. McJamerson et al (1989) found that the most important distinction between Black persisters and non-persisters was participation in financial aid and scholarship programs. Those African-American students who participated in these programs were more likely to stay in college than those who did not. Also the ability to receive emergency funds quickly (financial assistance) received high priority from non-persisters. Rice (1989) conducted a study to identify social, financial and academic factors that affect African-American's retention/attrition status. The student responses indicated that these students dropped out more for financial reasons rather than for social and academic ones. King, (1999) encourages colleges and universities to provide more funding for minority students particularly in areas with low minority enrollments.

Others argue that the institutions must continue to finance programs in order to make an impact on retention (Hillmer, 2001). These studies reveal that the presence of financial resources plays a role in students' persistence in education. None of the above studies, however, examines the impact of finances on mathematics major's decision to persist. This research study attempts to add to the research literature by understanding specifically how and if financial concerns impact high-achieving African-American mathematics majors' decision to persist in mathematics through college.

Social cultural factors, academic factors, psychological factors and financial factors shape African-American students' experiences on college campuses and impact their retention. The identified factors helped shaped the theoretical framework guiding

this study**.** Given the population examined in this study, similar factors may be identified by the students in this study as impacting their persistence as mathematics majors.

African-American High Achievers in Higher Education

The above literature review examined the factors that have been identified as having impact on African-American students' retention in higher education. In this literature, there is little about the experiences of those African-American students who excel in college. There is a growing body of research that looks specifically at the experiences of African-American high achievers in college (Allen, 1992; Fries-Britt, 1998; 2000), a group who have been historically absent from the discussion on minority student retention. In order to understand the population in this study, it was necessary to explore this research.

Although her work does explore high-achieving African-American students in higher education, Ford (1995) provides an understanding of some of the social, cultural and psychological factors that influence the presence and persistence of African-American middle and high school students in gifted education. Since there is scant research on African-American high achievers at the collegiate level, some of the factors identified in her research on these secondary students can be used to understand the experiences of the high achieving or gifted students this study seeks to examine. Using quantitative methods, gifted, potentially gifted and average students were surveyed regarding their perceptions of factors that negatively or positively affected their achievement. Nine variables were investigated: racial/ethnic identity, test anxiety, attitudes toward school subjects, support for the achievement ideology, and perceptions of the learning environment. She examined the influence of psychological, social (peer

issues and societal injustices) and cultural/familial factors. The data from the gifted African-American students reveal the following: 1) they had few anxieties that negatively impacted their achievement, which implies a high level of self-efficacy; 2) they expressed few concerns regarding peer pressure and relationship; 3) students reported strong, positive family achievement orientations; 4) gifted students expressed favorable attitudes about the learning environment and enjoy learning; and 5) they had positive attitudes about school subjects particularly mathematics and science.

One of the limitations of this study was that it was that it did not explore the nature of variables that were found. For example, when students report having positive family achievement orientations, it is not clear the nature of these orientations and how they were cultivated by the family. Also, gifted students report favorable attitudes about the learning environment; however, it is unclear of what specific characteristics of the learning environment were perceived favorably. The findings of this study can, however, provide insight into some of the social, cultural and personal factors that may influence high achieving college students in mathematics.

Fries-Britt (1998) examined the academic, social and racial experiences of high-achieving Black students enrolled in the Meyerhoff Program, a merit-based scholarship program for students in math, science, and engineering. Guided by Tinto's retention framework, the researcher conducted interviews with twelve students in this elite mathematics and science based program. The results of this study reveal that high achieving African-American students experienced a lack of belonging or what the researcher refers to as Black Achiever isolation. The students in the study had limited exposure and interaction with other Black high achievers in high school and were in

honors and advanced classes with White peers. Therefore, they saw themselves as a small minority of Black students who had high academic ability, which created a sense of separateness from other Black peers and not truly belonging with their White peers. This feeling of isolation, however, was somewhat diminished by their participation in the Myerhoff program because being in this program afforded them the opportunity to engage with other like-minded peers. The researcher also found that although it was beneficial for the participants to be surrounded by other high-achieving African-American peers, it was also important that they remain connected to the extended Black community and not be perceived as "special" or separate from other African-American students on campus.

Fries-Britt (1998) also found that being in a "race specific" program contributed to the success of the Meyerhoff program participants academically and socially. Having academic and social resources, being apart of a Black high-ability community for which they could harness support, and having supportive faculty were the benefits most often cited by the participants. The results of this study suggest that the high achieving African American mathematics majors in this study may have similar college related experiences. Although the participants in Fries-Britt's study were not mathematics majors, they were apart of a science and mathematics based scholarship program and have comparable academic profiles as the students in this study. Although students in this study may not be a part of a scholarship program such as the Myerhoff program, the factors of positive peers support and structured college scholarship programs are some possible factors that may have had a positive impact on the population examined in this study.

Fries-Britt and Turner (2002) examined 34 successful Black junior and senior college students from a predominately Black university (HBCU)and a large multi-campus traditionally White institution (TWI) in order to understand the academic and social experiences these students at both types of institutions. Coincidentally, a large percentage of the participants attending the HBCU had transferred from a TWI; therefore the researchers were able to compare their experiences from both types of universities. The researchers found that establishing academic and social support, the level of campus involvement, and cultivation of their self- confidence academically and culturally were central to these students' positive experiences at predominately Black institutions. Students attending HBCU's had more faculty and peer support than they had while attending PWI's, were more socially involved in campus activities, and gained more energy and increased confidence which had a positive impact on their retention at HBCU's. The Fries-Britt and Turner study suggests that even the most academically talented Black students required support, encouragement both social and academic integration in order to be successful in college. Although this study did not speak specifically about successful African-American mathematics majors, the authors noted that several of the participants were in science and mathematics related disciplines. Hence, similar factors may be found in the high achieving mathematics majors investigated in this study.

African American Students' Success in College Mathematics and Science

Research suggests that African-American students fail to persist in mathematics and science related disciplines in college (Seymour & Hewitt, 1997). Seymour and

Hewitt (1997) conducted a longitudinal study that explored students' learning experiences in SEM-related disciplines at several universities. This study found that students switched out of SEM-related majors because of several challenges they faced in these disciplines including: lack of support by teachers and peers, an overly competitive academic environment, poor performance in first year courses, and demanding academic workloads. In particular, this study found that students who initially majored in mathematics had the highest dropout percentage of all of the SEM-related majors. Although this study's data was not aggregated by previous academic achievement, it can be concluded that many of the students declaring majors in SEM related disciplines had stellar academic records from high school. Even some of these high ability African-American students find themselves challenged by mathematics related disciplines and particularly struggle in their first year mathematics courses (Asera, 2001; Oakes, 1990, 1998; Triesman, 1985; 1992), which some researchers argue is critical to their subsequent success in mathematics-related majors (Oakes, 1990).

Grandy (1998) conducted a longitudinal study of high-ability minority students in order to construct a comprehensive model to investigate why some high-ability minority students persists follow through with their plans to become scientists and engineers, while others with the same plans do not persists. She defined high ability students as students who scored 550 or more on the mathematics section of the SAT. Using a path analysis model, the researcher defined four measured variables and eight latent variables that were used to explain Asian-American, African-American, Indian, Mexican American, and Puerto Rican students' persistence in science and engineering fields. The four measured variables were gender, type of college attended, self-report science grade

point average, and outcome status five years after high school. The latent variables were defined as socio-economic status, math and science achievement, social development, minority support, science ambition, importance of security, importance of services, and commitment to science. Persistence was defined as participants who were currently studying or working full or part time in science and engineering related fields.

The most important variable affecting science ambition was minority support, which was defined as the extent to which students had minority or female role models, had advice and support from their own ethnic group, and had a dedicated minority relations staff. In addition, she found that the largest effects on the decision to make a commitment to science in the sophomore year were science ambition, which was a direct effect of minority support systems. Students in four year colleges were more likely to take advantage of minority support systems and "their enthusiasm for science led them to make a strong commitment to a science or engineering career by their sophomore year" (p.605). This data suggests that minority support had a positive effect on students' retention in SEM-related fields and that students who made a commitment to these disciplines by sophomore year were more likely to have had this minority support. This study focused on several minority groups and did not aggregate the data to represent the experiences of African-American students; however, the majority of the sample was African-American students, which means that the findings strongly reflect the views of this population. It was not clear from the research, however, the specific components of minority support that had the greatest impact on their retention in science and engineering disciplines, nor was it clear that mathematics majors were represented in the sample. This study will seek to explain what factors had the most impact on mathematics majors

persistence in the disciple and will seek to understand these experiences from the students' perspective.

Given the challenges that these high ability African-American students face in higher education and particularly in mathematics related disciplines, there has been a growing interest in understanding what factors impact students' success in college mathematics courses (Asera, 2001; Triesman, 1985; 1992). In his landmark study, Triesman 1985 found that several of the African-American and Latino students in his University of California at Berkeley classes were not being successful in his college calculus class. These students were doing poorly despite having a willingness and desire to learn calculus and strong academic backgrounds. However, his Asian students were succeeding in the course and were equally motivated as his black students. What Triesman found was that black students tended to study in isolation and were unclear of how well they were performing relative to their classmate. While their Asian counterparts worked individually and in peer study groups, shared problem solving strategies, asked questions and compared answers, and always knew where they stood relative to their classmates. From these observations, Triesman developed the Emerging Scholars Program which was designed to facilitate student success in calculus by incorporating the use of peer learning groups. Students volunteered to participate in the program and attended supplemental problem solving workshops which ran parallel to calculus class and recitations sections during the semester. In these sessions, small groups of students worked on challenging problems under the guidance and monitoring of graduate students.

Triesman (1985) found that the African-American and Latino students who participated in the program outperformed students with similar academic backgrounds

who did not participate in the program. The success of this program was credited to students being allowed to work in peer support group, having support and guidance by graduate students and the engaging in challenging mathematics problems. In fact, the program was so successful that it became a model for several similar programs throughout the country (Asera 2001; Duncan & Dick, 2000)).

The results of Treisman's work and subsequent studies done on his Emerging Scholars program and other similar programs (Asera, 2001; Treisman 1992; Bonsangue, 1992) reveal that African-American students who participate in the Emerging scholars program were retained at higher levels that non-participants (Bonsangue, 1992), outperformed their peers who did not participate in the program (Triesman, 1992), and were more likely to persist in mathematics and science-related discipline (Asera, 2001). What is missing from this work is an in depth understanding, from the perspective of the students, of the particular aspects of the program that made the most difference and why. It will be useful for researchers to understand some of the non-academic positive impacts this program had on the mathematics majors' success and persistence in the disciplines. The current study seeks to fill this important gap in the current research.

Summary

Research indicates several factors that have been shown to impact African-American students in mathematics and retain these students in college. In addition, research discusses some of the specific experiences of African – American high achievers in colleges and universities and some insight into how to increase the performance of African American students in college mathematics. Although there is a growing body of research on the experiences of African-American undergraduates in mathematics and

science related disciplines, there is little research specific to mathematics majors. Mathematics majors, I believe, have unique experiences because of the nature of mathematical inquiry.

While existing research provides important information on what impacts African-American students in mathematics and higher education, more evidence is needed on the experiences of high achieving African-American students who persist and succeed as mathematics majors Future understanding is needed on the nature of these students' educational and mathematical experiences, and these studies must include the voices of these high achieving students. In formed by existing research, this study examined the family, educational, communal, and personal factors that these students perceive as having impacted high-achieving African-American mathematics majors success and persistence in mathematics.

This review of literature relevant to the current study informed me of the factors that might be important to my study and might arise during my data collection and analysis. The literature review aided in the development of my initial research questions and developing the theoretical framework guiding this study. In addition, this literature informed my development of my initial interview protocol and start list of codes

CHAPTER III

METHODS

Overview

The purpose of this study is to examine the personal, social and cultural experiences that that influence high-achieving African American mathematics majors to persist and succeed in mathematics. The major research question guiding this study is: What perceived factors contribute to high achieving African-American junior and senior mathematics majors' decision to persist and succeed in mathematics through college? This study also seeks to answer the following research questions:

1. In what ways do these high-achieving students perceive the role of educational institutions, family and the community in their success and persistence in mathematics?
2. How do these high achieving students perceive their own role in their success and persistence in mathematics?

In this chapter, I provide an overview of the methods that were used in this study, including a discussion of qualitative research and traditions of inquiry, and discuss the results from a pilot study that served to shape the framework for this study. This chapter also explains participant selection, data collection, data analysis and reporting procedures. This is followed by a discussion of trustworthiness, credibility, and ethical issues and concludes with the limitations of this study.

Qualitative Research

This study employed qualitative research methods. This methodology is ideal when seeking the insight and perspectives of the participants and understanding an

understudied group or other phenomena (Creswell, 1998; Maxwell, 1996). Qualitative methods can be used to explore areas about which little is known or areas in which we want to gain novel understandings of a well known area (Stern, 1980 as quoted in Strauss and Corbin, 1996). David Krathwohl in his book Methods of Educational and Social Science Research stated that: "The qualitative point of view of research involves understanding how the world looks to the people being studied and how those people act on that information. Qualitative research findings are local and context bound. Multiple interpretations may be quite acceptable depending on how various persons perceive the data being explored (p. 237)." The goal [of qualitative research] is not to reduce those meanings to a single generalization or explanation. Instead, the objective of qualitative inquiry is to understand the individual's perspectives, lived experiences, behaviors, thoughts, and feelings (Strauss and Corbin, 1996). Given the goal of qualitative research and the purpose of this study, employing qualitative research methods for this study allowed me to best investigate and answer my research questions.

There are various types of qualitative research paradigms, and I considered many different types for this study including phenomenology, grounded theory, interpretive case study and life history. After much research and debate, I choose to use an interpretive case study approach for several reasons. In this study, I explored and sought to understand students' personal, social and cultural experiences and their perceived impact on students' success and persistence in mathematics. I am not seeking to develop a theory of success that would emerge from the data, which made using a grounded theory approach inappropriate (Creswell, 1998).

In phenomenological studies, the researcher seeks the central underlying meaning of the experience(s) and seeks to provide a comprehensive description of it (Creswell, 1998). In this type of inquiry, the researcher assumes that there is an "essential, invariant structure or essence of a particular experiences and seeks to "suspend" his or her own biases and prejudgments in order to "uncover" the essence of the participants' experiences (Creswell, 1998). This paradigm was inappropriate for this study because of my own personal experiences as a high achieving African- American mathematician and educator. I would not be able to nor did I have a desire to "set aside" my own biases. I believed that the unique perceptions and experiences of these students were valuable in their own right, and I wished to explore them thoroughly and deeply. Although I recognized that there may be some commonalities in these students' experiences, I am interested in having each of their stories told without a need to extract a particular unifying essence. Hence, using a phenomenological approach was not appropriate for this study.

While investigating life histories, I found that this research method was also not aligned with the goals of the study, nor did it allow me to focus on the particular experiences that I was seeking to understand. Plummer (1983) stated that a life history is a full-length book's account of a person's life in his or her own words (p 14). The researcher is looking at the person's entire life and how his or her life reflects cultural, personal or societal themes. Since my research questions require me to understand particular perceived experiences, I felt that this paradigm was too broad to be effective at answering my research questions.

Case Study Methodology

Interpretive case study was chosen because it is used to organize and report the actions, perceptions, and beliefs of an individual or group under specific conditions (Romberg, 1992). A case study is an exploration of a "bounded system" or case (or multiple cases) over time through detailed, in-depth data collection involving multiple sources of information rich in context (Merriam, 1988). The system is bounded time in place, and it is the case being studied, which could be a program, an event, an activity, or individuals (Creswell, 1998), and is selected because it is an example of some phenomenon of interest (Merriam, 1998). When, the focus of the case is unique and requires study, it is known as an intrinsic case study (Stake, 1995). For this study, each student is bounded by his or her experiences and will be considered an individual case. Each student's social, cultural and personal experiences will be explored as an individual case, and the goal is not to merely describe these experiences, but to understand the nature, meaning and relationships among these experiences. In addition, cross case analysis was used to understand generalizations across student's experiences. "By comparing sites or cases, one can establish the range of generality of a finding or explanation (Miles and Hubberman, 1984 p 151 as cited in Merriam, 1998).

Unlike descriptive case studies that merely present a detailed account of a phenomenon (Merriam, 1998), interpretive case studies are used to develop conceptual categories or to illustrate, support, or challenge theoretical assumptions held prior to data gathering (Merriam, 1998, p 28). Merriam (1998) asserts:

> The level of abstraction and conceptualization in interpretive case studies and conceptualization in interpretive case studies may range from suggesting relationships among variables to constructing theory. The model of analysis is inductive. Because of the greater amount of analysis in interpretive case studies,

> some sources label these case studies "analytical." Analytic case studies are differentiated from straightforward descriptive studies by their complexity, depth, and theoretical orientation (p.28).

Given the purpose, objectives, and research questions guiding this study, I believed that using a case study approach helped me better understand the students individually and collectively. In addition, this approach allowed me to seek what is common and what is particular about the cases (Stake, 2000).

Pilot Study

A pilot study was conducted because of the limited amount of research on this population. As an exploratory tool, I conducted the pilot study for the following reasons: to find out whether or not high achieving mathematics and mathematics majors existed and if it was possible to have access to students that fit my criteria. Once it was determined that the population would be accessible to me, I needed to test my interview protocol to determine if it would yield the kind of data that was needed to answer my research questions. I used the results from the pilot study to clarify, refine or extend my research questions and/or interview questions. Finally, I used this preliminary data to inform and refine my research context and theoretical framework

Results from Pilot Study

The pilot study revealed several issues that informed this study. First, I learned that the population that I intended to study did exist, although appropriate research participants were difficult to find. I contacted four local universities in search of participants for this pilot study. Twelve students were referred to me; however, nine of the students did not fit the criteria for this study. A large number (six) of the African/African American students were first or second generation Americans, meaning

that they or their parents were of direct African or Caribbean decent. These students did not fit the study criteria because I was particularly interested in native-born African-Americans, who have been historically marginalized by the dominant White society in the United States.

Of those students who were African-American, as defined for this study, most did not meet the academic requirements to participate in this study. Two of the students were not yet in their junior or senior year, as a math major, while two of them did not have the minimum grade point average to participate in the study. Of the three students that fit the study's criteria, one young lady agreed to be interviewed for the pilot study. This young lady, Lisa (pseudonym), was 22-year-old senior mathematics major from Virginia. She attended a historically black university on the east coast. Her career goal was to become a high school mathematics teacher and further her studies in mathematics in graduate school. She had a 3.2 grade point average, and was in her last semester in undergraduate school.

I learned from this student that caring teachers, parental encouragement, mentorship/role models, mathematics related career goals, and personal determination were major influences on her decision to major in mathematics in college. Lisa stated that a particular mathematics teacher in high school had a major impact on her mathematically and personally. When she fell behind in her Calculus class due to a personal tragedy, this teacher spent hours after school and during lunch to tutor her. In addition to the care and encouragement of her math teacher, the student commented that her attitude of determination and "stick-to-it ness" was instrumental in her persistence and success in mathematics. Interacting with caring professors and seeing

mathematicians as “real people with real lives” encouraged her to continue in the face of hard times and difficult courses. Caring educators and parental support were two major factors found in other studies that examined this population (Moody 2000; & Martin 2000).

When asked why she chose a major in mathematics, Lisa cited her desire to help other students and to become a teacher as the main motivators for her decision to major in mathematics in college. She saw a need to encourage other students to do well in mathematics, and she mentioned throughout the interview that mathematics was very important in several career fields. When asked about how she saw mathematics and its importance to others, she discussed the importance of mathematics and its relationship to other courses. She explained:

> Because that there is so much that you can do if you ask them, if you ask a young person what they want to do when they are older, or a profession. They could list off a bunch of things and I will guess and say that six or seven out of ten will some how have math related to them. They want to be an engineer, they have math. They want to be an accountant, they have math. It [math]is always going to be sneaking in there somewhere. It may not be calculus, but it is always going to be some aspect maybe statistics. But it always going to be something that is creeping in from a math aspect. So if you have a basic foundation and understanding of how to do mat. Not necessarily calculus, but like how to think through a problem logically, it easier to go into other fields and be like ok, well you need to started here and end up here, and I need to take these steps to get there, you can apply that to something else.

The results of this pilot study revealed that caring teachers, determination, and an interest in the subject were key influences on this high-achieving African American mathematics major’s decision to persist and succeed in mathematics. Specifically, the role of parents and the community were ongoing themes in this student’s experiences. In my initial research design, I intended to only investigate the students’ educational

experiences. As a result of this pilot study, I refined my theoretical framework and research questions to specifically investigate the influence of family and the community on these students' success and persistence in mathematics. I also found that the student possessed several personal attributes such as determination, a positive attitude toward mathematics and an understanding of the usefulness of mathematics, which influenced her success and persistence in mathematics. Subsequently, my interview protocol was modified to include questions that addressed community and family experiences. My research questions were modified as a result of this study to include a specific focus on these students' cultural and social experiences.

Finally, I realized that locating high achieving African-American mathematics majors was much more challenging than I anticipated. Initially, I intended to select African- American students from only two universities, one historically black university (HBCU) and one predominately white university (PWU). However, I realized that many of the African American students who were referred to me were of African or Caribbean descent and did not meet the criteria for the study. In fact, the HBCU chosen for the study had only one African-American student that fit the criteria, the young woman who eventually participated in the pilot study. I realized that it would be difficult to find the number of participants needed for the study if I did not include two more universities in my sample. Hence, my research design was modified to include high achieving students from two HBCU's and two PWU's. However, I was unable to find enough participants that fit my criteria from HBCU's that were willing to participate in this study; hence, I had to modify my research design.

Participants

Purposeful sampling was employed to select the participants in the study. Purposeful sampling allows the researcher to select people for a study based on the belief that this sample can contribute to or expand the knowledge base (Schloss & Smith, 1999). As Merriam (1998) explains, purposeful sampling is used when an investigator wants to "discover, understand, and gain insight and therefore must select a sample from which the most can be learned (p. 61)." The student is the primary unit of analysis since I am interested in the phenomena of their perceived experiences. Therefore the selection of the participants was critical to the design and goals of this study. The following four criteria were used to select the eight participants for this study:

1. Multi-generational African-Americans born in the United States and received their pre-college education in the United States
2. Current junior or senior students in a four-year college or university.
3. Cumulative GPA of 3.0 or better and have declared majors in mathematics.
4. Taken or are taking mathematics courses above the Calculus sequence

Scholars (Ogbu 1991; Goodwin, 2002) argue that multi-generational African-Americans have uniquely different experiences than those students who have migrated here from other countries. Hence, when conducting research on African-Americans, a distinction should be drawn between these groups. For example, in her study of socioeconomically and educationally disadvantaged minority students succeeding at an elite university, Lattie Goodwin (2002) distinguished between the experiences of three groups of students, which she called the pleasers, the searchers and the skeptics. The pleasers were first generation immigrants who immigrated to this country sometime before college; the searchers where second generation immigrant students whose parents immigrated to the United States sometime before the students were born; and the skeptics

were multigenerational United States citizens who were historically disenfranchised by the dominant White society. She refers to the skeptics as involuntary immigrants and have different cultural, social and educational experiences (Goodwin, 2002; Ogbu, 1991) based on their historic marginalization in this country. For this study, I sought mathematics majors who were multigenerational African-American citizens.

Given the highly selective criteria and the difficulty of finding students that satisfy all of the above criteria, I found it necessary to select students from several different universities on the east coast. I contacted a total of five different universities on the east coast. I sought participants from public and private historically black colleges and universities (HBCU's) and private and public predominately white universities (PWU's). The schools were selected because of their accessibility to the researcher, and the department chairmen from these universities agreed to assist with the project. Four students from one mid-size PWU, three students from a research one PWU, and one student from a HBCU agreed to participate in the study.

I selected participants in the spring of 2005 from a list of possible student participants supplied by the chairman of the mathematics department from each university. I contacted each student and asked them would they be interested in participating in the study. I them scheduled an initial meeting with each student and explained the specifics of the study. When the student agreed to participate, I gave them the informed consent form to sign and asked the students for referrals of other possible participants. During the spring semester of 2005, I scheduled two 60-minute individual interviews at each of the students' campuses. As themes arose from the data that needed to be discussed further, an additional interview and/or one group interview was scheduled

with the participants as needed. The students schedules and time availability determined the exact times and places of the interviews. (See appendix for interview schedule)

Data Collection

Data was collected over a six-month period. Each participant was interviewed two times and these interviews are my primary sources of data. “In case study research of contemporary education, some and occasionally all of the data are collected through interviews (Merriam, 1988, p 71).” Guided by my research questions, I created a protocol with general open-ended questions designed to understand the students’ parental, educational, communal and personal experiences and their perceived impact on their success and persistence in mathematics. Each of the questions in the interview protocol was designed to gain information about the students’ experiences in the above areas. Table 1 represents the interview protocol for the initial (first) interview with each student. Table 1 also identifies the research questions that each interview question addressed.

Table 1 Interview Protocol

Research Question:	**Interview Questions**
General Background	1. Can you tell me a little about yourself? 2. What is your educational and family background? 3. How do you like college? Being a mathematics major?
What perceived factors contribute to high-achieving African-American junior and senior mathematics majors’ decision to succeed in mathematics through college?	4. What would you say was the key(s) to your success in mathematics?
What perceived factors contribute to high-achieving African-American junior and senior mathematics majors’ decision to persist in mathematics through college?	5. Why did you choose to major in mathematics? 6. Explain some of the experiences that lead to your decision to pursue mathematics in college?
In what ways do they perceive the role of	7. Was there anything in your school experience

educational institutions in their persistence and success?	that influenced you to achieve in mathematics? 8. What experiences in school (K- college) would you say most shaped your success in mathematics?
In what ways do they perceive the role of the community in their persistence and success in mathematics	9. How did your community impact your achievement in mathematics? 10. Were there any community programs, persons or activities that influenced your decision to continue in mathematics?
In what ways do they perceive the role of their families in their persistence and success in mathematics	11. How would you describe your family experiences? 12. What role did your family play in your success in mathematics?
In what ways do they perceive their own role in their persistence and success in mathematics?	13. What kind of mathematics student are you? 14. Is there anything about your personality that you would say makes you a successful mathematics student?

Interviews took place at the students' university in an informal setting agreed upon by the participants and lasted approximately 60-minutes each. At the beginning of the interview session, I clearly stated the purpose of the study and gave the participants an opportunity to ask questions whenever they needed. In the initial interview, students were asked the questions from the interview protocol, and the students' responses were recorded using a tape recorder. The initial interviews were reviewed by the researcher and transcribed by a professional trascriptionist. Once the transcripts were received, they were checked by the researcher for accuracy and completeness and were also reviewed and edited by participants.

The data from the first interview was used to develop subsequent interview protocols for each of the eight participants and these interviews were tailored to the individual participants' responses from the first interview. The second interviews were designed to understand and to clarify the researcher's understanding of the students' perceptions and experiences that were revealed in the initial interview. As the data were gathered in the second interview, I looked for repetition in the themes to determine if I had reached a point of saturation. Saturation was determined if there was no new information from the individual case or the cross analysis. Sample questions from these second interviews can be found in Appendix C.

Once first and second interviews were conducted with each participant, case summaries were created by the researcher and distributed to each participant in a third in-person, email or telephone interview. Participants clarified and edited these case summaries for accuracy and several participants provided addition feedback to help complete the summaries. Due to students' schedules and availability, I was unable to successfully implement a group interview as intended in the initial research design. However, I was able to obtain the data needed to reach data saturation and I conducted follow-up interviews with all participants.

Role of the Researcher

As the researcher, I had two roles: an insider and research instrument. Qualitative researchers reject the notion of an objective researcher who is "unbiased." In fact, much of qualitative research embraces the idea that the researcher's role is critical because it is her eyes through which the data is seen. Hence, the researcher has to constantly be aware

of her own bias and practice reflexivity throughout the research process. The term reflexivity refers to the process of critical self-reflection on one's own biases, theoretical dispositions, preferences and beliefs. By being reflexive, a researcher understands herself as a part of the setting, context and social phenomenon she seeks to understand (Schwandt, 2001). Being an African-American female who has been successful in mathematics, I saw myself as a part of the community I sought to understand. This made my role very complex, and I had to keep in mind that I was revealing these students' stories and perspectives and not my own. As the participants used terms that are familiar to me, I made sure that I captured their experiences and not my own. I did this by employing member checks, participant reviews, and keeping a reflective journal throughout the data collection and analysis process. In addition, I worked to be constantly aware of the different layers of my own biases as a researcher/participant, mathematics educator and African-American female.

I saw my role as a researcher as one who collaborated with and probed students for their expert knowledge. In fact, I believed that there stories were a primary source in understanding their success, and it was my job to present a credible and authentic representation of their stories. I also understood that I had a strong personal connection to this research, and this connection cannot and will not be dismissed. My role as researcher impacted this research in a variety of ways. First, the primary source of data for this study was gathered from my personal interviews with students. Hence, these interviews were conducted with extreme care and in a conversational and emergent manner. Secondly, although these interviews were informal and conversational, I probed the participants in a variety of ways in order to completely unpack the nature of their experiences and the

subtle and salient meanings imbedded in their conversations. Having possibly gone through similar experiences, I shared my own story with the participants. Sharing these stories provided richness to the conversations and extended my understanding of data. In conclusion, as the primary research instrument in this study, I saw my role as instrumental in all phases of data collection and analysis. Understanding my roles, values and bias allowed me to be thoughtful, critical and sensitive to the research participants, their stories and the research process.

Data Analysis

My research questions required me to understand students' cultural, social and personal experiences and their perceived impact on their success and persistence in mathematics. My theoretical framework was guided by several identified factors from research; however, because the population I investigated (African- American high achieving mathematics majors) are not adequately studied in the literature, I was unclear how these factors would "play themselves out" in the students' stories. Hence, I felt it necessary to use data analysis methods that provided some structure and yet remained flexible enough to allow for unexpected themes to emerge. Several methods of data analysis were considered for this study. Ultimately, I decided to use a combination of coding strategies advocated by Miles & Huberman (1994), Strauss and Corbin (1998) and Ryan and Bernard (2002) because I felt that these strategies were best suited to analysis the interview data that I collected. In addition, I utilized NVivo qualitative software to assist in the organizing, coding and retrieval of data.

Since I relied exclusively on interview data, it was very important that this data be clear, accurate, and complete. To ensure this, each interview was transcribed verbatim by

a professional transcriber. To ensure accuracy in transcription, the researcher proofread each interview transcript and each transcript was given to the participant for review, clarification, and editing.

"Coding forces the researcher to make judgments about the meanings of contiguous blocks of text. The fundamental tasks of coding is sampling, identifying themes, building codebooks, marking texts, constructing models and testing these models against empirical data (p. 78). Using these tasks as a guide, I began my analysis by compiling a start list of codes that were derived by major themes and ideas from my theoretical framework (See appendix). This start list of codes was generated from my theoretical framework that included social and cultural factors that have been identified in mathematics literature as having impact on African-American students' success in mathematics and the college success and persistence literature on African-American students (Miles & Hubberman, 1994). The start list of codes were adjusted, expanded and refined as data was collected and analyzed. As outlined by Miles and Hubberman (1994) and Ryan and Bernard (2002), I developed second level codes also known as pattern codes after the initial coding of the data. These codes were used in latter stages of data collection as patterns between and among participants become clear. These patterns were the basis of preliminary themes and assertions. These themes were induced from the data itself (Ryan & Bernard, 2000). These emerging themes and patterns were tested against the data to look for discrepant evidence (Maxwell, 1996). Searching for counterexamples and conducting respondent validation was used rigorously throughout the data analysis and reporting process (Boaler, Ball & Even, 2003). Using these

strategies allowed me to rigorously examine the data to assess the validity of my claims and increase standards of quality and validity of the findings.

Although, I was not developing a theory, I felt that the coding techniques and procedures for developing grounded theory advocated by Strauss and Corbin (1998) would also be used to deeply analyze the themes and relationships that emerge from the data and will be useful in single case and cross case analysis (Merriam, 1998). Strauss and Corbin (1998) advocate the use of open coding. This is a process through which concepts are identified and their properties and dimensions are discovered in the data (p 101). Many of the concepts I used in my data analysis began with my start codes, and I used open coding to further uncover, name and develop concepts. I coded the data by hand and using NiVivo. In this phase, I dissected, examined, and compared events, actions, and objects for similarities and differences, which helped with the discrimination and differentiation among concepts and categories (Strauss and Corbin, 1998). Axial coding, the process of relating categories to their subcategories and linking them at the level of properties and dimensions, was also used in analysis. This process was used to "reassemble" data that were fractured during open coding, thereby helping me form more precise and complete explanations about the phenomena (p 124). These tools allowed me to "open up texts and discovering its meanings and variations (p.71)" These strategies were used in both the single case and cross-case analyses.

In addition to these coding strategies, I used memoing as a way to organize and record my own thoughts, ideas, insights and hunches. These written accounts of analysis consisted of code notes and theoretical notes. As discussed in Strauss and Corbin (1998), code notes are memos containing the actual products of coding, while theoretical notes

are those that sensitize and summarize the researchers' thoughts and ideas about theoretical issues. Both types of memo strategies were used in this study to help the researcher make sense of the data, reflect and analyze the meaning of the data and develop and test emergent themes and assertions. These memo books served as another means for understanding the data and generating themes and assertions.

The following table represents my timetable for data analysis and reporting:

Table 2: Timeline for Data Analysis and Reporting

Dates	Activity
October 2004	Finalize Proposal Pilot Revised Interview Protocol Modifications of Protocol
November 2004	Proposal Defense IRB completion Participant Selection
January 2005	Initial Participant interviews Transcription and Data Analysis Initial Member checks Audit Team meeting
March 2005	Second Interviews Transcription and Data Analysis Development of Initial Themes Member Checks
June 2005	Group Interviews (if needed) Third Participant Interviews (if needed)
July 2005	Data Analysis Meetings with Peer Debriefer and Audit Team Revisit Literature review based on emergent findings
September 2005	Initial Analysis Report given to Participants for review and feedback
April 2006	Rough Draft of Dissertation manuscript submitted to Advisor Rough Draft Revisions
May 2006	2^{ND} Draft submitted to advisor and Committee Revisions of manuscript

July 2006	Dissertation Defense

Ethical Issues

To ensure the ethics of this study, several precautions were put in place. Each of the eight students selected for the study were given informed consent forms and were made explicitly aware of the goal of the study. At this time each participant was advised of his or her rights as a participant and informed of their right to withdraw from the study at any time. Also, the names and locations of the participants remained anonymous throughout the study. At the conclusion of the study, all manuscripts and data were safely stored in a locked file cabinet.

In addition to ensuring the anonymity of the participants, I maintained a standard of reciprocity between the participants and myself. Reciprocity is a part of the larger ethical-political process of building trust, cultivating relationships, and demonstrating genuine interest in those whom one studies and is an important part of field work (Schwandt, 2001). By employing this ideology, the researcher and the participants benefited from the research process, and I believed that this mutual gain was very important in the research enterprise. By providing academic and social support, encouragement and an opportunity to tell their stories, the participants benefited from their participation in this study. The participants and I served as critical experts and they consulted and treated as such. This study was designed to benefit the participant and myself because they got an opportunity to tell their stories of success, and I get the benefit of learning from them. Every effort was made to ensure that this researcher/ participant relationship were equal and balanced.

Trustworthiness

Issues of reliability traditionally focus on issues related to whether or not this study's findings will be consistent under similar conditions. In qualitative research, one does not necessarily seek reliability, but rather that the findings of the research are trustworthy. This means that the results of the research were done with a level of rigor such that the findings of this research "makes sense **(**Merriam, 1998)." In order to address issues of trustworthiness, I made clear my biases throughout the data collection, analysis and reporting. Also I created data storage and retrieval systems that are organized and properly stored, by using several methods such as two hard copy filing systems, one at home and one at school, several computer storing devices, and a special email accounts. In additon, I clearly documented data collection procedures and analysis protocols.

Researcher Bias

I had several biases that affected the reliability of this research. I had a very personal interest in this topic because I am an African-American female who has been successful and persisted in mathematics through college. I have been interested in promoting the participation and achievement of African Americans in mathematics for a number of years. This interest started in the 8^{th} grade when I felt a sense of empowerment and success when a wonderful and passionate mathematics teacher realized that I had the ability to understand mathematics. I believe that there are identifiable factors that impacted students' decision to pursue mathematics, one of which is teacher influence.

In high school, I had a zest and respect for mathematics that I think contributed to my consistent performance in the subject. I was not real sure where this enthusiasm originated, since I did recall any significant mathematics related activities for which I

engaged; however, my enjoyment of the subject blossomed in 8th grade. I quickly learned, however, that my peers did not share my enthusiasm or level of achievement. By the time I was in 12th grade, I had taken enough mathematics courses to be eligible for Calculus. There was no class offered, and my dad and I had to request that it be given to me. Hence, I came into this research with the underlying assumption that parental influence was also I factor in ones' persistence in mathematics. After completing my undergraduate degree in mathematics, I began teaching in a local high school. I found that even some of the best and the brightest in the school were not successful in their mathematics courses. And I was interested in understanding why this was the case.

When I began looking into literature about African American student's performance in mathematics, I found underachievement, learned helplessness, lack of positive role models, mathematics anxiety, lack of interest, encouragement and prerequisite knowledge, as explanations of the dismal performance of African-Americans and other minorities in mathematics. There were very few stories of success about African-Americans. I knew that there had to be another story. A story of achievement, motivation, success and high performance, my own story, my have been there for the telling yet no one appeared to tell it. I was not the only one who had a story of success in mathematics, and. this led me to think about investigating African American students who are successful in the subject.

To me, mathematical inquiry is very important and useful for all students. And I believed by looking at those who have been successful in the disciple, I could uncover the keys to success that I can pass on to others. Since there is little research on this population, I thought it would greatly contribute to mathematics education research.

Practically, we may be able to increase the numbers of African Americans in higher mathematics classrooms. As the primary research instrument in this study, I found it imperative to share with the reader my own experience, since it had an impact on my research analysis and results. In order to control for these biases, several strategies including member checks, peer debriefers, an expert debriefing team and using rich description were employed to increase the validity of my findings.

Credibility

Whereas issues of reliability stem from whether or not measurement procedures yield the same or similar answers whenever they are carried out, validity deals with the extent to which the answers revealed are "correct (Kirk and Miller, 1986)." Issues of validity revolved around two fundamental questions: Is the researcher observing and measuring what she is intending to observe and measure? Is this a plausible and credible explanation for the account? In qualitative research, one is primarily concerned with whether or not the research is credible**.** In order to ensure credibility with the research findings, I employed several criteria for verification in this study. Given that the goal of this study was to understand the educational, community, family and personal experiences of highly successful African American mathematics majors and their perceived influence on their success, I insured that the finding accurately reflect the students' stories and perceptions. In order to insure that the stories being shared were those of the participants and not merely my own autobiography, I was very explicit about my own researcher bias and perception, and I employed rigorous and consistent standards of quality throughout the research and reporting process**.** The following is an explanation

of the specific validity strategies that were used throughout this study to ensure accuracy of research findings.

Member Checks

I employed member checking which would allow participants to review and edit transcribed data. After each interview and preliminary analysis, a copy of the transcript and the researchers' preliminary assertions were given to the participants. The participants were asked to review the manuscripts and interpretations and make any corrections that they deem appropriate. Their changes were an ongoing component of the data collection and analysis. This insured that the interpretation of the researcher reflects the participants' views**.** This feedback from the participants was used as evidence regarding the validity of the account. As explained in the data analysis section, I also searched for disconfirming evidence throughout data in an attempt to falsify proposed claims. This process added to the rigor and believability of the final findings and results.

Peer Debriefer

In order to further insure the credibility of my findings, the researcher employed three peer debriefers. These peer debriefers were fellow graduate students and recently graduated doctoral students in education who were familiar with mathematics education and/or qualitative research methods. These students, serving as outside reviewers, examined the transcripts and emerging findings periodically during data collection and analysis. These debriefers provided additional feedback on the researcher's interpretations and further insure the credibility of the study's findings.

Expert Auditing Team

To increase the trustworthiness and credibility of my research findings, I formulated a debriefing team of fellow African-American mathematics and mathematics education professionals. This three-member team of experts consisted of one African-American mathematician, one African-American mathematics educator and one recently graduated high achieving mathematics major. The purpose of this team was to audit and verify emergent research finding and interpretations. In addition, they provided the researcher valuable feedback about the perceived legitimacy of findings based on their own experiences. This consultant team, given their own personal experiences in mathematics education, provided additional expert knowledge at several phases of data analysis and reporting. This team was consulted two times during the data collection and analysis process.

Rich Description

In order to insure the accuracy of research data and subsequent findings, each participant interview was transcribed verbatim to ensure accurate representation of what they have said. This type of data collection allowed the researcher to use the participants' actual words to confirm data findings. This is known as using "rich data" that are "detailed and complete enough to provide a full and revealing picture of what is going on (Maxwell, 1996, p. 95)."

Limitations of the Study

Since the study only reflects the experiences of these particular students, the findings are not generalizable to all successful African-American mathematics majors. This study used these eight students' voices as a means to gain insight into the lives of

other students of similar backgrounds; however, it must be noted that the findings cannot be used to generate a general theory that explains success and persistence for all students. Another limitation is the size of the sample. I only interviewed eight students for this study, which is a small number of participants. This again limits the generalizability of the results.

Furthermore, I did not interview students who are not successful in mathematics nor am did I investigate non-African American students. This limits my ability to compare and contrast the experiences of high achieving African American students with the experiences of other students. By specifically selecting participants who are successful, I narrowed the pool and therefore did not look at a diverse population of students. This prohibited the researcher from the ability see if the findings also applied to other types of students including high achievers of other races and ethnicities and other disciplines.

Since one of the goals of this study is to understand, from the participant's perspectives, their family, educational, communal, and personal factors that influenced these students' success and persistence, this study is limited to the recollection and perspectives of the students. Since I relied exclusively on interviews and self-report data, the data was driven solely by the accounts of the participants. This can be considered a limitation because the researcher did not observe the students in their natural environment, nor did she interview significant others to collaborate the students' accounts.

Since America's top universities heavily recruit high achieving African American students in mathematics, another limitation of this study is not including students who

attend top tier universities. Since the participants in this study were selected from local public colleges on the east coast, the results of this study is limited to the experiences of students at these types of universities. Students attending highly sought after and competitive schools such as University of California at Berkley, Massachusetts Institute of Technology and Yale may have been able to give further insight into the experiences of high-achieving African-American students.

CHAPTER IV

FINDINGS

To understand the family, educational, community and personal factors that contributed to high-achieving African-American mathematics majors' success and persistence in mathematics, I interviewed eight students. The students selected for this study were African-Americans who were born and raised in the United States, junior or senior mathematics majors, and maintaining a 3.0 or better GPA. In this study, persistence is defined as continuing to remain in the mathematics pipeline through college, while success is defined as students who are performing well as defined by their college GPA. By interviewing these students individually and collectively, I gathered the information necessary to answer my main research question:

> What perceived factors contribute to high achieving African-American junior and senior mathematics majors' decision to persist and succeed in mathematics through college?

This study also sought answers the following sub questions:

1. In what ways do high achieving mathematics majors perceive the role of educational institutions, family and the community in their success and persistence in mathematics?
2. How do they perceive their own role in their success and persistence in mathematics?

This chapter presents the results of my data collection and analysis. It begins with a brief overview of the major themes that I found in the cross case analysis. These themes are presented using the metaphor of gravitational pull toward success, which I believe

captures the essence of participants' experiences. Next, I provide a description of the eight African-American mathematics majors interviewed for this study. Following these case descriptions, I will explain how family, educational institutions, personal characteristics, and the community influenced their success and persistence in mathematics at each phase of their academic journeys. These influences are described in four chronological stages: pre- formal educational experiences (0- 4 years of age), elementary school experiences (grades k-8), secondary school experiences (grades 6-12) and post-secondary experiences. I explain how the family, educational, personal, and community experiences that contributed to these students' success and persistence in mathematics at the various phases of their educational trajectories. Finally, I present some of the obstacles that these students faced in high school and college as they persisted in their mathematics careers.

Overarching Metaphor that Describes These Students' Experiences

In the Newtonian view of gravity, entities or objects are attracted to each other by a force, determined by the mass of each object and the distance that separates them. The "pull" of an object is determined by its mass, and the more massive an object, the stronger it's gravitational "pull" is on objects with less mass. Hence, the object with smaller mass seems to be "drawn toward" the object with larger mass, unless they are so far apart that this pull is not experienced.

These students I studied perceived their trajectory through mathematics in ways that suggest a "gravitational attraction" toward success. Their parents, teachers, and peers seemed to "pull" them toward success because all of these entities seemed to be aligned to encourage the students' success. The alignment of expectations and support by parents,

schools, and peers, provided a *critical mass of influence* that seem to attract the student's toward success, despite any negative influences that may have been presented to them. In these students' perception, they seem to have "no choice" but to succeed in school and mathematics because they "had to," given all of the structures set up for their success. It was clear that the student did have a choice whether or not to succeed in mathematics. However, their individual wills seemed to be overshadowed by the strong parental, school, and peer support systems that were directing them toward success and persistence.

In general, the students' experiences began with caring, supportive, and engaged parents who instilled success-related values in their children, provided early educational experiences, encouraged them to succeed and advocated for them in school. In most cases, mothers created the foundation for their formal school career, while the fathers cultivated an early interest in mathematics. Both parents provided consistent reinforcement for their children's success and provided the first layer of this *mass of influence* toward success.

These students received an additional layer of influence when, early in their academic careers, they were tested or recommended for accelerated academic programs (e.g. gifted and talented and honors programs). In some cases, their parents were key advocates who navigated academic pathways for their children to insure their entry into these elite programs. These special programs provided a structure and access to accelerated curriculum, competent and caring teachers, and ultimately advanced mathematics coursework in high school, all of which were key elements supporting their successful persistence in mathematics.

In high school, the students continued in accelerated and advanced placement programs. In these programs, they had caring teachers who held high expectations; they participated in rigorous mathematics coursework; and they had positive peer support and influence. All of these factors helped them to remain successful in school mathematics. In high school and, more strategically, in college they created peer support networks that helped them overcome the challenges of being minority students in these accelerated programs.

With strong home and school support structures, students perceived that they had "no-choice" but to excel and persist in mathematics. Their parents, teachers, and peers seemed to expect them to continue to excel in their mathematics coursework, and they obliged this expectation. In high school, they were "encouraged" to continue in gifted and talented, advanced placement, honors, and higher-level math courses by their parents, teachers and counselors. Being guided toward these courses in high school gave them the necessary mathematics background needed to declare college majors in science and mathematics related disciplines, and therefore strengthened the mass of influence promoting their success.

In college these students were selected for various scholarship programs. Each student received some sort of financial support and/or scholarship and was a part of structured or loosely-structured academic and social systems that supported their persistence in mathematics. Examples of the support they received included financial support, study groups/peer support, faculty mentoring, summer bridge programs, and program staff support. While in these programs, faculty mentors played a key role in their

persistence in mathematics by encouraging them to pursue degrees in mathematics after they became dissatisfied with their initial choice of science or engineering major.

After declaring majors in mathematics, the participants were motivated to stay in the discipline because their future goals required it, and they had access to peer and faculty support. They also believed that their mathematics degrees would be an asset to whatever occupations they choose, although many were unsure of their specific career paths. Critical to their persistence as mathematics majors was a reliance on peer support networks. These networks provided both academic and social support and served as an extended family structure, particularly during challenging times, and provided another layer of support that was critical to their persistence as mathematics majors. Because of the high expectations and support provided in these programs, these high achievers were "pulled toward" success in their college mathematics courses.

Prior to high school, the personal factors contributing to their success in mathematics were a growing enjoyment of mathematics and an attitude of compliance, which spoke to their experience of having no choice but to be successful and continue to persist in their accelerated mathematics coursework. However, in high school and college, the idea of "dropping out" of the mathematics was not a consideration for several other reasons. During these years, the participants' personal agency became more apparent, and the students became more active agents in their persistence in mathematics. The reasons students gave for persisting in mathematics were more a reflection of their own personal interests and agency than merely complying with others' expectations. First, seven out of eight of them truly enjoyed mathematics and had career aspirations that required an extensive mathematics background. Even though none of them initially

declared math as a major, they believed that mathematics was important and perceived that taking advanced mathematics coursework was valuable. Several of the participants reported that they enjoyed the challenges of mathematics and believed in their ability to meet the challenges of the discipline. It was apparent from their experiences that they had high self-efficacy (Wigfield &Eccles, 2000) in mathematics. In addition, many saw themselves among an elite group of African-American students who were given the opportunity to "be with the best and the brightest," who tended to be white students in their honors classes. Therefore, they felt a social responsibility to "represent" their race or the African-American community and serve as role models for models for other African-American students.

The African- American community's role in the persistence of these high achievers consisted primarily of a social obligation that these students felt to continue down this "God ordained road" of mathematics because they were blessed with mathematics talent. The "community" provided these students with a sense of "groundedness" and allowed them to see their success in a broader social context. Success was not perceived merely as a personal accomplishment; their success reflected the success of others and doing God's work. In addition, the community gave them a sense of spiritual connection that was utilized in times of extreme challenge and difficulty. All of these entities combined provided the leverage that was needed to remain in mathematics through college and provided another critical circle of influence that impacted their success.

Despite the many positive influences of home, school and community, several participants described some perceived entities that presented obstacles to their success.

These forces included lack of African-American role models, negative perceptions of faculty, and their own feelings of not being "a mathematical genius." Despite these perceived negative factors, these high achievers had a strong enough support system and positive influences that they these opposing forces could not steer them off course of success.

Participants

Case 1 Anita James

Anita James hails from a large predominately African-American suburban town outside a large metropolitan area. She was raised by both of her parents who were both in mathematics related fields. Her mother is studying to be an accountant, and her father is a computer scientist, who served in the Navy. At age 13, her family moved to a small predominately white town outside a large city. Her parents encouraged her to always do her best in school and they were generally supportive of whatever academic decisions she made and encouraged her to take courses that she enjoyed, which tended to be mathematics. Anita's older sister, a mathematics and economics major, was also a source of support. When Anita was in high school, she shadowed her sister for a day in college. This experience helped shape her decision to pursue a mathematics related discipline in college.

When she attended a predominately African-American school system, she was tested into a gifted and talented program in early elementary school, and continued in gifted and talented programs through middle school. After she transferred to the predominately White county, she noticed that the schools were a lot better than those in her former school district. They were better in the sense that there were more sections of

honors courses. A guidance counselor reviewed her transcripts from middle school and suggested that she consider the honors track in high school. On this track, Anita continued to take advanced mathematics coursework through precalculus and regretted not "doubling up" on her mathematics courses so that she could take Calculus in high school.

Ms. James was not a mathematics major when she first entered college. She was initially a chemistry major and changed her major to mathematics after a conversation with a faculty mentor. Anita is currently 20-year-old junior mathematics major who attends mid-sized predominately white college on the east coast. She is an honor student with a 3.5 GPA and participates in the Sterling scholarship program, a prestigious mathematics and science related scholarship program.

Case 2 Tennille Smith

Born and raised in a town outside of a large metropolitan city, Tennille Smith was raised primarily by her aunt, who took guardianship when Tennille was 8 years old and her parents unable to support her. Before age 8, she was raised by both of her parents and describes herself as a "daddy's girl." She admits that her father spent a lot of quality time with her when she was younger, and she had a close relationship with her father when she was a young child. Although she has a biological brother and sister, she considers herself an only child since neither of them lived with her. Her aunt set high expectations and demanded that she do the best in school. Tennille recalls that her aunt knew she was academically talented, and her aunt communicated that it was her job to do well in school. It was her aunt who insisted that she attend the local science and technology program in high school because she wanted her to be exposed to challenging work, avoid

negative influences from neighborhood friends, and ensure that she had expanded opportunities in the future. She does not recall an early interest in mathematics before entering school; however, she remembers having a general interest in math in elementary school.

In elementary school, Tennille competed in several mathematics challenges, which required her to perform mathematics quickly and accurately. Her teachers recognized her talents and pushed her to excel in mathematics, particularly her fourth grade teacher. Based on these early experiences in mathematics, she began to realize that she was good in mathematics and developed confidence in her mathematics abilities. She continued to achieve in middle school. She admits that she did not have to work very hard for good grades in math and would sometimes be shunned by other students for her seemingly effortless understanding of mathematics. It was not until high school that she began to experience more challenging mathematics classes and really had to work harder to achieve good grades because she was a part of a demanding science and technology magnet program. Tennille admits that she had "no choice" but to do well in this challenging program because she could not drop out of the program. Her aunt would not allow it, and the academic program that she was in required her to take mathematics courses through Calculus III.

Initially Ms. Smith was an education major; however, she switched to mathematics major in her freshman year. Tennille is currently a 21-year-old honor student and senior mathematics major at a Historically Black College on the East Coast with a 3.6 grade point average.

Case 3 Tina Jones

Tina Jones is originally from North Carolina and moved to a small town in Virginia when she was 5 years old. Her mother is an educator who eventually earned a Ph.D. and currently serves as the principal of an innovative elementary school in the area. Her father served in the Navy and currently works as a civil servant in the government. Tina said, “He works on fighter jets and does some type of engineering related work.” Her family relocated quite a bit because they were in the military; however, Tina asserts that she is basically from Virginia since this is where she spent the bulk of her childhood. Tina admits that her mom was an inspiration to her particularly because she worked on her master’s degree while raising three small children. She watched her mom “struggle” to finish her master’s degree and her Ph.D., and her mom always was a source of encouragement and support for her children. Her mother expected her to do well in school, and Tina came to expect the same of her. Since her mother was an elementary school teacher and guidance counselor, she knew how to help her daughter navigate the school system. She made sure that Tina took the best teachers and was a part of the top programs and classes in school. Her mother also worked with her at home, although she was not much help with her mathematics work. Her dad watched discovery channel with her and helped her with her mathematics and science coursework in high school. It was her dad who helped foster an early interest in mathematics.

Supported by her mother, Tina was placed in classes with teachers who pushed her and challenged her in mathematics. She participated in hands on activities, played games which incorporated mathematical ideas and did very challenging mathematics work. Because of her rigorous elementary experiences, she found middle school honors

classes relatively easy and teachers less creative compared to elementary school. However, this did not deter her from being interested in mathematics. In high school, she attended what she called a “regular” public school and was in honors and Advanced Placement courses, where she was one of two black students in her classes. She performed very well in her mathematics courses and believed that mathematics appealed to her hands on nature. Also in high school, she was a part of a club for students who were interested in majoring in engineering. In this club she mentored elementary students, participated in summer internships, and engaged in several mathematic and science related activities. The experiences she gained from these activities solidified her intention to become an engineer.

Tina currently attends a local Predominately White University (PWU) and is in a prestigious science and mathematics based scholarship program. She initially declared a major in chemical engineering, but became dissatisfied with that program. After tutoring mathematics in the Upward Bound Program the summer after her junior year and speaking with a White female mathematics faculty member about opportunities available to a mathematics major, she decided to change her major to mathematics. Ms Jones is currently a 22 year old senior majoring in mathematics at a local PWU on the east coast with a GPA of 3.4.

Case 4 Joyce Michaels

Joyce Michaels is a native of New Jersey in a racially mixed suburban community, with a strong orthodox Jewish presence. She grew up with her mom, a former bank worker, who was a stay at home mom, and her father who was a civil engineer. She and her two older brothers were educated in the public schools, and her

parents were both very active in their children's education. He mom had high expectations of her, and was very careful about monitoring her after school activities. Joyce admits that her mother's presence in the home while she was growing up was key to her having a structured and supportive home life. She was not able to "run amuck" like many of her peers, and she never had to attend after school or summer programs. As the only girl, she admits to trying to keep up with the guys and loved electrical trains and mechanical things. Her dad did mechanical drawings and loved electrical trains and would play with her and her brothers, which she attributes to sparking an early interest in mathematics. She recalls when she was in the first grade; her dad bought home a computer game with multiplication and other mathematics related activities and became intrigued with trying to figure out how it works.

In third grade, she tested into the Gifted and Talented (GT) Program after being encouraged to do so by her teacher, an African American female. In her GT mathematics classes, she participated in fun mathematics projects and competitions and her love for mathematics grew and impacted her success in the subject In middle and high school there was no GT Program and anyone could take honors courses, and she elected to do so. In high school, she took Advanced Placement (AP), course through Calculus II and passed both AP examinations. She attributes being around other motivated students was a key factor in her continued decision to take advanced math courses. There were few behavior problems in these courses, and this allowed the teachers to engage them in special projects, activities and accelerated learning.

Joyce has a full scholarship to a large research-based PWU on the east coast. This scholarship requires her to do research and participate in internships. She was initially a

biology major with the intention to attend medical school. However, since she came to college with enough mathematics credits (from taking the AP exams in Calculus I and II), she realized in her freshman year that she missed taking math courses. She changed her major second semester of her freshman year. Joyce is currently a 19-year-old junior mathematics major with a GPA of 4.0.

Case 5 David Simmons

David is from a small town in North Carolina and for the first seven years of his life was raised in a two parent home with his two brothers. His mom was a stay at home mother and his dad was a county worker. However, things changed when his parents divorced and his mom had to work to support the family. As a result, David became his mom's support system. His mom just recently completed her degree in social work and works as a social worker; however when David was growing up, his mom did odd jobs while trying to complete her undergraduate and graduate degrees. He grew up "below the poverty line," as he recalls, and did not feel particularly motivated in school. His mom did her best to monitor his progress in school; however, her work schedule prevented her from doing this consistently. His mom knew that he was bright; however she was unaware of his giftedness in mathematics. She was generally encouraging to David and supportive of his choices.

David tested into the accelerated track in early elementary school when it was discovered that he was talented, and he continued on this track trough middle and high school. In high school, he tested into the International Baccalaureate program and took mathematics courses through Calculus I. He admits that it was a white female teacher who took an interest in him and encouraged him to take advanced mathematics courses,

even when his grades did not reflect his mathematics ability. This teacher knew he was good in mathematics by his in class participation and interest; however, his grades did not reflect his ability. It was later discovered that due to home related pressures, he was not doing the required studying and homework. Despite his performance, she would simply sign him up to take advanced mathematics courses, and he would not resist taking these courses. David credits this teacher and his love for the subject for his persistence in mathematics in high school. He also believes that he has natural talent in mathematics and understands mathematics with little effort.

After high school, David did not apply to college, and he went to the military for four years. He was unaware that he could go to college on scholarship and his mom did not have the financial resources to pay for him to go. In addition, he admits that he did not know what he wanted to do after high school. His mother encouraged him to pursue the military since it would be a good way for him to get experience and eventually pay for college. He credits the military for giving him the discipline he needed to follow through with his commitment. After serving four years in the military, he decided to leave and pursue a college degree.

David was initially a computer science major and switched to mathematics because he did not want to spend hours in front of the computer, and he really enjoyed mathematics. David received a very competitive minority scholarship, which requires him to maintain a 3.0 GPA, take two technical courses a semester and participate in mentorship and other activities. He is a 24-year-old junior at a large Predominately White University on the east coast with a GPA of 3.2.

Case 6 Karen Johnson

Karen hails from a small, predominately white town outside of two major cities. She grew up with her mom, dad and two older brothers. Her mother is an educator and her dad is a businessman who became the first black member of the school board in her county. She refers to her parents as trailblazers and staunch advocates for education, for their children and other African-American children in the county. They instilled in her the importance of education and expected her to do well in school. From an early age, her mom would work with her at home on schoolwork, using workbooks, educational activities and trips, problem solving and other strategies to prepare her for school and make sure she was ahead once she was in school. She was not allowed to watch TV or play until she had completed her schoolwork and her moms "assignments," which were generally more challenging than her class assignments. Her dad was not quite as active in her education; however he communicated the same high expectations as her mom. Although neither of her parents were "math people," they knew the importance of mathematics for future job opportunities and made sure that she was exposed to mathematical experiences as a young girl. And it was her mother who advocated that she be placed on the accelerated academic track in first grade. In addition to her parents, growing up with two successful talented brothers motivated her to do "even better" than they did. It was a challenge for her to her to outdo her brothers, and she wanted to be one of the boys. This was an additional driving force for her in her mathematics career.

She was always in gifted and talented programs in elementary through high school and she was often one of few African Americans in her classes. Although there were a sizable number of minorities in the school for her county, she noticed that these

other African-American students were in lowered tracked mathematics classes. She was always in the top math group although she never considered herself one of the mathematicians in the class. In high school, she took honors and Advanced Placement mathematic course through Calculus III. In these courses, some teachers, mainly white females, knew she was smart and encouraged her to stay in the math track. However, she encountered white male teachers who did not seem to encourage her as much.

Having received a Sterling scholarship for science, engineering and mathematics majors to attend college, she initially declared a major in chemical engineering because she had participated in high school internships in chemistry. As a chemical engineering major, she realized that she was practically a mathematics major and she enjoyed her mathematics courses better than her chemistry courses and she could not see herself doing engineering for the rest of her life. Karen is currently 20-year-old senior mathematics major attending a mid-size Predominately White University on the east coast with a GPA of 3.6.

Case 7 Michael Brown

Michael is from a large predominately African-American County on the east coast where he grew up with both of his parents. His dad works for the pentagon, and his mom is an accountant. Although Michael was not clear exactly what his dad did, he knew that his father had a degree in the sciences. When he was younger his parents encouraged him to participate in space camps and programs that were geared toward science and mathematics. His parents provided general encouragement and stressed that he do things that he enjoyed. This encouragement was not mathematics specific, and they did not try

to push him into anything that he did not want to do. In addition to his parents, he has one brother and four sisters, one of his sisters is an aerospace engineer.

In elementary school, he was in the Gifted and Talented program and continued in this program through middle school. Coming from middle school, he took a test and had the appropriate grades to be placed in a well-known science and technology program in high school. In this program, he was required to take a math class and he started with Geometry and continued through AP Calculus. In high school, he simply tolerated mathematics and did not feel that mathematics was a useful discipline to pursue as a career. He did not see the relevance of math in high school and was not aware of the usefulness of mathematics nor did he know what careers he could pursue with a mathematics degree. He simply took advanced mathematics courses because they were easy and fun for him and he got good grades in the subject, and even went through AP calculus.

Michael received a prestigious science based academic scholarship at a Predominately White University on the east coast. Initially he was a biochemistry major, but since he did not enjoy chemistry and was not interested in majoring in biology, he decided to change his major. He sought the advice of a Calculus II professor who shared with him some of the opportunities available to mathematics majors. He wanted to keep his options open, so he decided to major in math because he learned that you can "do basically anything" with a mathematics degree. Michael is a 21-year-old senior mathematics major and computer science minor at a PWU on the east coast, with a GPA of 3.8. He is involved in several student organizations and serves a mentor to other students in SEM programs.

Case 8 Shanice Jackson

Shanice hails from a suburb of a major east coast city. Her mother is white and her dad is African American. She has a brother that is mixed and an older sister who is white. She identifies herself as bi-racial unless she has to compete for scholarships, then she identifies as a minority student. Her dad died when she was eight and her mom was her primary caretaker throughout most of her school years. Her dad was an editorial writer for a major newspaper. Her mom was a history teacher in the local school system and eventually became the principal of a middle school.

She acknowledges that neither of her parents were "math people" in mathematics; however, her mom was proud of her daughter's achievements in mathematics and science and gave her general encouragement and support in all of her classes. Her mother really cared about her and would not allow her to get C's in her courses. Shanice believes that having parents that encouraged and cared about her was key to her success in all of her subjects.

In third grade, she took a test to enter into the Gifted and Talented (GT) mathematics track in elementary. Although she did not meet the score to enter the gifted and talented track, her mom insisted that she be placed in the GT track because she knew that this would be best for her daughter. As an insider to the school system, her mom knew that GT students received the best attention. She also knew that once a student was in GT courses, they would remain in this track for their entire schooling. She admits that participating in GT programs in elementary and doing science projects were critical to her success early in mathematics.

In middle school, she finished geometry in the eighth grade and continued on through each subsequent mathematics course through middle and eventually high school. When asked what made her continue to take mathematics courses, Shanice contends that she was just on this track since she was nine and continued to take mathematics courses. Although she did not love the courses, she did well in these courses and liked them enough to stay in them. She found mathematics challenging at times and admits that she never had much of a problem with it.

In high school, she went to a multi racial/multi-ethic school and took honors and AP courses in mathematics and science with diverse students; however, there were only a few African American in these classes. She took courses through Calculus II and did well in these courses, although she admits that she never had a strong passion for mathematics. She admits that she didn't study that much; however, she would spend "quality time" when she did study.

Shanice transferred from a mid-size private Predominately White University on the east coast to a large public PWU on the east coast. She was not admitted into the honors program since her current university does not have an honors program for transfer students. She did, however, receive a minority student scholarship for some of her expenses. In this minority scholarship program, she interacts with others in science and mathematics majors and participates in several SEM based activities. She admits that she choose math as a major because she was encouraged to choose a major instead of being undeclared. Shanice is a 20-year old junior mathematics major at a large research PWU on the east coast.

The following section will discuss the ways in which the family, educational institutions, the African-American community, and the participants themselves impacted these students' success and persistence in mathematics during each chronological phase of their lives. The first chronological phase highlights the participants' **pre- formal educational experiences** where the parents and family played the most significant role in setting the foundation for their subsequent success in school mathematics. Next, the chapter investigates **elementary school educational experiences** where students were first exposed to formal mathematical study. At this stage, students had access to caring teachers and an accelerated mathematics curriculum that prepared them for rigorous mathematics coursework in high school. In **secondary school**, they participated in gifted and talented, advanced placement and science and mathematics programs that charted an accelerated mathematics track for which they had "no choice" but to follow. Because the participants were in these programs, they were expected to take advanced mathematics coursework that would prepare them for science, engineering and mathematics related fields in college. In the final phase of their academic trajectory, **post-secondary school**, these high achievers were selected into structured and loosely structured scholarship programs that gave them access to faculty and peer support, internships and professional conferences that the participants perceived were vital to their selecting mathematics as a major and their persistence in the disciplines. During each of these phases, parents, educational institutions, the community and the participants themselves played very different roles.

Cultivating an Environment for Achievement: The Role of Preschool Educational Experiences on Mathematics Achievement and Success

Participants highlighted several key roles that their parents played in their success in mathematics, particularly in their early years. The roles that their parents played were multi-dimensional and spanned their entire educational careers. However, their parent's influence was most prominent in their early years up until their entry into accelerated programs in elementary school. In this section, I discuss the primary ways that these students perceived the role of their parents in their success and persistence in mathematics.

All of the students in this study began their formative years in a two-parent household, and the values and structures of these households provided a firm foundation for their entry into school and into formal mathematics learning. In these households, their mothers and fathers had important and distinct functions. However, both parents' presence in the household had a positive impact on their preparation for school, initial interest in mathematics and science, and early mathematics-related experiences. In many of these cases, being from a two-parent home allowed one-caretaker, primarily the mother, to take an active role early in their child's education.

The Nurturing Mother

The mothers provided essential pre-school experiences and supervision that created a nurturing environment that helped foster an initial interest in learning and provide an academic structure that was essential to these students' latter success in school. For example, Karen Johnson recalls a conversation she had with her mother about her infancy years. Her mother shared with Karen how she taught her the alphabet as an

infant and that she was an early talker. Also her mother exposed her to mathematical concepts before she entered pre-school. Karen credits these early experiences with giving her a head start over many of her peers.

> Well, with my mom- when we were little, she sat in the crib and she used to do letters and stuff like that, and different things where we'd learn the alphabet and stuff like that, at 11 to 12 months. We all talked early. I know I started talking, she said 9-10 months or whatever. ... My mom taught us how to count and everything like that. And every time we went someplace, oh, what's 1 + 2? And what's 2 + 2? … But I know before 5, I know I could add and stuff like that.

By giving Karen this attention as young child, she received the skills to be an early talker and reader, which gave her a head start in her preparation for formal schooling. In addition, she specifically recalls her mom providing early mathematical experiences. Because of her family structure, her mom was available to provide these experiences and take an active role in her child's learning.

David's mother also provided a nurturing and academically focused home environment that helped to cultivate his early interest in learning. In his early years, David's mother was a stay at home mom and was able to give David considerable attention. He asserts that this early supervision was important to his initial interest in learning and readiness for school. Like Karen, David was also an early talker and reader and his mother taught him to count at an early age. Having these early educational experiences had a positive impact on his school success, and he attributes this to his mom being available.

> My mother really didn't work for the first several years of my life, and her just being there to watch Sesame Street with me. I think I had an advantage over a lot of kids because my mother actually took us to the library…She had nothing else to do but to just take care of us. And watch out for us, and take us to the library. ..Her [being there] in the beginning, just watching Sesame Street with us, making sure I learned how to tie my shoes before I went to kindergarten. I was just ahead of the game early on… In kindergarten I was way ahead of those kids. I probably

> should've went straight to first grade.…I knew how to count, I knew how to add….My mom was a beast, like Mom can you leave us alone? Like, can I watch cartoons? No, I want to see you write your name twenty times. So, that helped me.

His mother being available to engage him in educational experiences early in his life helped prepare him for school and gave him a head start when he entered elementary school. These early experiences were so significant that he makes a distinction between his childhood experiences before and after his parents divorce.

> My childhood can be split into two terms: pre-divorce, happy time, Mother, I had a stay at home mom. You know, I came home from elementary school- Yeah. I had lunch waiting on me. She had nothing else to do but to just take care of us.

Before his parents divorced, his mother had the time to invest in his education; however, once his parents separated, David's mother no longer had the time to monitor his education as she had when she was married. This illustrates how being in a two-parent household provided a structure that allowed David's mother to actively engage in her child's learning. Both parents played a crucial role in their subsequent success in school and mathematics.

In Joyce's narrative, we see similar experiences. Joyce recalls that her mom being home to monitor her socially and academically was a key component to her early success in school. Because Joyce's mom was home, she was able to provide needed supervision and pre-school experiences that influenced Joyce in positive ways. Although, Joyce could not recall any particular kinds of activities she engaged in with her mother, she perceived her mothers' presence in the home as very influential in her latter success in school.

> She [my mother] always wanted me to be an engineer, so I think she was supportive of me being within a technical field. I think her presence in the house when I was younger contributed to the way I grew up. Like, my mom was always

> home so I never had to do after-school programs. .. I know her presence has had a huge influence on how I turned out. When we were out of school, a lot of people's parents are at work, so you know they're running amok in the streets. My mom was home.

We see from the above vignettes that these participants' mothers played a major role in providing early educational experiences that shaped their interest in learning and readiness for school. In addition, these mothers provided needed supervision that provided a nurturing and structured home environment for their children. Although not all of these early educational experiences were mathematics and science specific, they were positive experiences that cultivated a love of learning, problem solving skills, and key reading skills. Having these skills helped these students place in Gifted and Talented and Accelerated programs in early elementary school. Being placed in these programs, we will see latter, gave them access to a particular kind of mathematics knowledge, which was key to their success in school mathematics.

Fathers Cultivating an Early Interest in Mathematics

In these two parent families, the fathers also played an important role in their children's educational lives, particularly in their mathematics learning. Many of the fathers, five out of eight, had technical or science based careers; therefore, they were proficient in mathematics and science and helped cultivate an early interest in science and mathematics. These early mathematics experiences with their fathers were particularly dominant in the majority of the female participants' experiences (4/6), and many of them perceived these experiences as being a key component in their initial interest in the discipline. This interest latter grew into a love for the subject that was essential to their persistence.

Joyce Michaels, whose father was a civil engineer, admits that her dad influenced her to be interested in mathematics. Being the only girl in this male-dominated household, Joyce was exposed to mechanical things her entire life. Her earliest recollections of being interested in mathematics began when she was in the first grade. Her dad bought home a computer game with multiplication and other mathematics related activities. She became intrigued with trying to figure out how it worked. She admits that she liked mathematics because it made sense and was straightforward. When asked if her father's occupation influence her choice to become a mathematics major, Joyce recalls:

> I definitely think that my father influenced me to be interested in math and science. I was never interested in engineering but I always did like math…I think my earliest exposure to being interested in mathematics- it had to be when I was younger and my dad bought me this computer game. ..I guess ever since then I always liked math because it always made sense, and it was just very straightforward I thought. .. We [Joyce and her dad] used to sit there and like put the circuit together so the train could work.

We see from the above except that Joyce's dad provided her with early mathematics related experiences that cultivated her initial interest in the subject. She perceived these early experiences with her father as key to her interest and subsequent success in mathematics. She notes that these experiences where "more advanced" than what she was learning in school, which reflects the idea that she began school with a head start over her peers. Tina, Karen, Anita and Michael, whose fathers were also in technical fields, shared similar experiences. Tina's father worked a variety of positions including working as a technician on a fighter jet. Although Tina admits that she was not certain of her father's occupation, she knew it was science and technology related. Tina describes how he was able to relate the science and mathematics concepts she was learning in school to the real world, which she found helpful in her own studies:

> He [her father] uses math every day. He'll tell me stories of him growing up, how engineers- he had to explain to them what to do, even though he doesn't have an engineering degree, he knew more about stuff and he had to show engineers how their blueprints were wrong. So, to me, my dad [could] relate what I'm learning about, to the real world. [Since he was] adding numbers and electrons, this is what my dad does! You know, he has to use this stuff [mathematics].

Anita, whose father was a computer scientist, gave her general encouragement and supported her decision to persist in mathematics. Although she does not recall any mathematics specific encouragement, she contends that her father valued mathematics and served as a positive role model.

Michael's father received his undergraduate degree in physical science and worked for the Pentagon in a science based field; however, Michael was not sure what he did for the organization. His father insisted that he participate in science and mathematics related programs. This insistence may have been a result of his father's own background in science and mathematics, although Michael did not say this specifically.

> Well when I was younger, they (his parents) tried to put me in summer programs, just to, like NASA summer programs or space camp, nothing that's solely based on mathematics…The summer program wasn't geared toward mathematics, they're more geared towards life science type stuff. And like aerospace stuff.

Although Karen's father's occupation was not directly related to mathematics and science, his job required him to interact with people in mathematics and science related fields. Through these interactions, he came to believe that mathematics and science were important for establishing a financially lucrative career and articulated these beliefs to his daughter. He stressed the importance of mathematics and science and encouraged her to excel in these subjects. He also facilitated her exposure to science and mathematics related activities in order to extend her understanding of concepts discussed in class. Karen recalls in our second interview:

> My parents, they weren't into math and science. But, they knew where the jobs were, and my dad hires people a lot for his company, and he works for an aluminum company in their like public affairs position. And he's like, all the money is here. … If we were reading something in science and I'm really interested, I'm going to ask my dad about it. You know, he's going to tell me what he knows about it. Or we'll watch the Discovery Channel program about it.

As evident from the above data, the father's occupation and/or interest in mathematics had an impact on the participants' early interests in science and mathematics and provided them with related support, encouragement and values that developed their interest in mathematics. Their fathers helped them learn to value mathematics and developed positive beliefs about mathematics. While the mothers provided early educational experiences and created a nurturing and academically rich environment. There is evidence to suggest that mothers taught their children basic arithmetic concepts; however, it was the fathers who provided the foundation for their child's interest in mathematics, which was an essential component to their success and persistence in mathematics.

Tennille, who grew up in a two-parent home until she was eight, did not speak about any significant pre-educational experiences with her female guardian nor did she discuss someone cultivating an early interest in mathematics. She shared how she moved from her mother's house at age eight to live with her aunt. Although her aunt held high academic expectations for her, there was no evidence of structured academic support at home or any early pre-school activities that enhanced her readiness for school. In Tennille's case, her early educational experiences in GT mathematics courses made a significant impact on her subsequent success in mathematics.

During this pre-educational phase, there was little evidence to suggest that the African-American community or the participants themselves played a significant role in

their success in mathematics. And since they were not a part of formal educational settings, educational institutions did not play a role at this phase, either. However, during their early educational period, parents continued to play a dominant role in their children's success in school; however, the role of the elementary school becomes more pervasive. What we learn in the following section is that the parents and educational institutions were viewed as partners in these African-American high achievers' successful launch into formal schooling.

Building Momentum: The role of Early School Experiences and Parental Advocacy in Their Success and Persistence in Mathematics

Once these students entered formal schooling, their parents continued to play a significant role in their children's success in school. One of the major ways that the parents impacted their success was by instilling in their children a variety of academic and social values that were necessary for their later success in school mathematics. Some of these values included an emphasis on hard work, discipline, the value of education, and giving back to the community- all of which later contributed to these students specific success in mathematics.

Success-Related Values

The parents of these high achievers instilled various success related values that were important to their success in mathematics. Since mathematics is a discipline that requires hard work, discipline, and strong prior knowledge, the values that these parents imparted proved useful throughout their mathematics educational pursuits. This influence did not necessarily begin when their children began school; however, it became more pronounced when they entered formal academic settings. In general, these students'

parents valued education, believed in hard work and discipline, and saw giving back to the community as fundamental values that were instilled in their children. Hence, they communicated these values to their children in a variety of ways, and these values supported their children's academic advancement. In addition, several participants (5/8) reported that their parents imparted a sense of community and spirituality that served them, particularly during challenging periods in their academic lives.

Karen recalls her parent's commitment to education and its impact on her success in school. Her parents' experiences in segregated schools shaped their beliefs about the importance of school and giving back to the community. These values stayed with Karen and provided a degree of motivation for her. She recalls:

> My parents were gonna find a way so that we could do things to be successful because they wanted more for us. They wanted more for the community …My dad always says if you don't take responsibility for your people, even though you don't want to claim them all the time, nobody else will. So I think that's why all of us feel like we have to do stuff for the black community, even though they might shut out my parents some of the time.

Knowing that her parents "wanted more for her," and encouraged her to "take responsibility for her community," Karen did not want to let her parents down and was willing to "comply" with her parents' expectations. Karen saw her success as a way to give back to the community. As we will see latter, this need to give back to the community was an important personal motivator for several of the participants' success in mathematics.

Karen also revealed how her parents modeled hard work and perseverance, traits that she adopted in her own academic pursuits. Her parents instilled in her that her "job" was to do well in school. When asked what the pay was for this "job," Karen replied:

> When we got good grades, we got you know money and stuff like that. … And my parents worked very hard so that their kids get what they wanted and they saw that we worked hard. Because they asked us to do well in school, that's what we did. Because we saw our parents work hard every day, and I guess that's what helped me work hard. Because I know how hard my parents have worked, and how many jobs they worked.

In Karen's case, her parents modeled working hard and encouraged her and her siblings to do the same. By modeling the success-related value of hard work, Karen's parents instilled this characteristic in her. As the above vignette reveals, even though she was rewarded with money for doing well in school, this was not the only reason she choose to succeed in school. She chose to do her best because she saw it as a "payback" to her parents for being a source of motivation and inspiration for her.

In David's case, he describes his mother as a go-getter. She instilled in him the importance of going after what was important and seizing every opportunity presented to him. Therefore, his mother served as a role model for David because he took on similar characteristics that helped shape his academic character. He credits his mother with helping him cultivate this character trait of going after what he wants, an attitude that helped him in his persistence in mathematics.

> [My mother would say] do whatever you can do, because you may not get this opportunity again. So she's very much a go-getter. And now, you know, I kind of have that attitude now. You know. Where, I'll apply for everything. You know, I show up for everything. I try to participate in everything.

David's mother planted seeds that encouraged him to take risks and go after opportunities that were presented to him. This characteristic was a key component to his success in mathematics since he admits that mathematics requires him to be willing to make mistakes and try various approaches in order to arrive at ultimate success.

When asked how she developed a strong commitment to doing well in school, Shanice credits her parents with instilling this commitment in her. Because of her upbringing, she perceived average performance as unacceptable and would therefore do what was required to achieve at a higher level. While discussing what experiences had a memorable impact on her drive to be successful in school and in mathematics, Shanice credits her parents with instilling important values in her as a young child.

> My parents [instilled a desire to be the best] from the beginning and when [I] started to get older, [I] realized for myself that it's [being successful in school] important to my future to do well in school. So, it's just important for me to do well. I don't want to get a C. I would be really upset if I got a C in a class. So, I guess like I just won't allow myself not to do well. If I feel like I'm starting to slip, then like I won't allow it to happen. You know?

Shanice's parents, just like several other parents of these high achievers, instilled a variety of success-related values that were perceived as having a positive impact on their success and persistence in mathematics. Values such as giving back to the community, valuing education, working hard and pursuing what was important to them were fostered in their children from an early age; therefore providing an additional layer of parental influences that shaped their success in mathematics. These students adapted these beliefs and values and they were key ingredients to their academic achievement, particularly in mathematics.

Parental Advocacy

The most intrusive way that these students perceived their parents impacting their success and persistence in school mathematics, is through parental advocacy. Parental advocacy is distinct from support and encouragement. Parental advocacy as defined in this study is parents taking intrusive actions to navigate their child's educational paths to ensure their success in school. This advocacy was most pronounced in the early

elementary school years where major educational decisions were made that set the course for the participants' entire school experience. Actions that reflect this behavior include parents being active in the school, making recommendations about the child's academic track, demanding that their child take particular mathematics courses, and advising them about ways to navigate educational and social institutions for their benefit.

In general, it was the mothers who advocated for their children. Mothers not only provided important pre-school educational experiences, as mentioned earlier, many students recall how their mothers pushed them once they were in school to be successful. Four out of eight of these mothers were educators and the other four mothers had education beyond high school. Therefore, they knew how to navigate the educational system to ensure their children's success. Shanice explains how her mother insisted that her daughter be placed in the appropriate classes to ensure that she receive maximum benefit from her educational experience.

> **…** My mom worked in a school system, so she knows what's up. Like the GT kids get all these best attention, and if you're in GT to begin with, that's the track for the rest of your life. ... She knew that it was important to get me in the GT classes and stuff. If you want to be successful, if you want your kid to be successful, then you should try to get them in the GT classes. Because if they start in GT in elementary school, they'll be in GT in middle school and high school, and those are the kids that are successful and, you know, you can get into good colleges and get scholarships and things like that.

Shanice's mother continued to advocate for her daughter even when she failed to meet the GT admissions score on the placement test. She further explains in a second interview:

> Everybody takes a [placement] test; I think it third or fourth grade you take a test to get into GT classes. … Depending on how well you do on the test, you're placed in either GT or [regular] classes. I don't know if they had honors or what… I didn't do well on the math part of the test actually when I was in third

> grade. And I wasn't supposed to be in GT math, but my mom made them put me in GT math.

Although Shanice did not test into the program, her mom interceded and persuaded the school to place her in the most advanced mathematics track. In a follow-up interview, she explains how her mother knew that by placing her in the advanced track in elementary school it would positively impact the rest of her educational career.

> Yeah, she knew that it was important to get me in the GT classes and stuff if you want to be successful. If you want your kid to be successful, then you should try to get them in the GT classes. Because if they start in GT in elementary school, they'll be in GT in middle school and high school, and those are the kids that are successful and, you know, you can get into good colleges and get scholarships and things like that.

This type of intentional interference on the part of the parent, particularly the mother, can also be seen in Karen Johnson's story.

> .. My parents made sure that I was on the accelerated track in elementary school. I was in Gifted and Talented, so I started from first grade on, and I always took honors courses…and I graduated from middle school at the top.

Both Karen and Shanice's mothers insisted that their daughters be placed in accelerated programs in early elementary school. The advocacy of Karen's mother did not stop with having her placed in the accelerated track in elementary school. Karen's mother, who was a teacher and guidance counselor, purposely enrolled her in certain courses that would challenge her academically as well as socially. While discussing her experiences in elementary school, Karen explains the advantages of having a mother who understood the educational system.

> [One of] the advantages of having your mother as head of guidance is she tried to make the schedule so it'd be conducive for me. And that's what most people who work in guidance [would do] if their children were there; they [would] try to make

> the schedule such that their kids wouldn't have to have teachers who they knew that they would struggle with. But sometimes my mother went ahead and put me in those classes with teachers that I would struggle with, because she [knew] I needed to experience that.

Elaborating on she meant by having teachers that she would 'struggle with,' Karen admits that her mother wanted her to experience teachers who would challenge her socially and academically in order to teach her how to overcome these challenges.

> **…**A lot of these teachers didn't have the social skills when working with her, so she knew that they weren't going to have the social skills with me. She was like, you're not always gonna get the teacher that you want to get. If you can't do well in a teacher's class who doesn't like you, and you don't like them, how are you gonna do well in any other course? Once you can do that [do well with these challenging teachers], you can do that with anybody.

Similar experiences were shared by other participants who had mothers who were educators. Tina, like Karen, went to a school where her mother taught; hence, she also understood the system and navigated the system on her daughter's behalf. When asked with experiences in elementary school influenced her most on her mathematics journey, she comments on how mom placed her in the most challenging classes.

> In elementary school I went to the school my mother taught at. She was a third grade teacher, and I went there from pre-K to fifth grade. And so she had a role in picking the hardest teachers for me to take. She made sure I was in the hardest classes. She made sure that I did not always have the teacher who's the nicest, but they wanted the most from the experience. So, from the beginning, I knew I had to put [out] more. I had to do more than, I wouldn't say anyone else, but my mother expected me to push myself more, and I came to expect it in myself, you know, to push myself more.

We see from the above comments that both Karen and Tina had mothers who were intentional about placing their daughters in challenging classes with demanding teachers. In these classrooms, their daughters could gain the academic and social skills to help them in the future and to learn how to deal with and overcome challenges. Karen's

mother knew that she would have a teacher with a “negative” attitude; however, she wanted her daughter to experiences a range of personalities and temperaments in order to teach her how to cope with challenging personalities. This type of intentional placement is a form of parental advocacy.

What is common in all of the above students’ experiences was that these mothers took intrusive actions that directly impacted her child’s academic trajectories. These mothers did more than simply tell their children that they could overcome challenges. They placed them in situations that required them to overcome challenges and build their academic and social character. This act of intrusion on behalf of their children is a key component of parental advocacy and the participants acknowledge that these acts of advocacy impacted their success and persistence in accelerated programs which includes mathematics courses.

As explained in the above sections, parents played a major role in preparing their children for formal school and advocating for them once they were there. In this section, I will describe the various ways that these students perceived the role of educational institutions in their success in elementary school mathematics. Because these students were placed in accelerated, honors and gifted and talent programs by the end of third grade through testing, parental advocacy and/or teacher recommendation, they had access to caring teachers and quality mathematics learning experiences that were offered to a select few African-American students. In these positive learning environments, students were able to thrive academically and their parents continued to support that their success in school.

Early School Experiences: Third Grade Placement

The third grade was a key year in many of these students' academic lives because it set the stage for their entire school careers. Although most of the participants were identified for advanced programs in third grade, one student was tracked as early as kindergarten. Even in this participants' case, she had to take an additional test in third grade to confirm her placement in the accelerated program. Joyce admits that her third grade teacher pushed them to enroll in the advanced program.

> Well, I think my third grade teacher was actually the one who told my parents to sign me up for the Gifted and Talented courses….I think just because she was a black female, and so I think she had a special interest in me as a black female student and the best student in her class. She was the one who told my parents to sign me up for the Gifted and Talented level, you know?

Joyce's teacher saw enough academic promise in her in the third grade that she "made" her parents place her in the gifted and talented program. It can be assumed from the above data that critical placement decisions were made in this grade that allowed the teacher to make this recommendation. Other students took at test that placed them in the GT program.

> Everybody takes a test in like, I think its fourth grade or maybe third grade, you take a test to get in GT or something like that. But everybody takes a test, and depending on how well you do on the test, you're placed in either GT or- I don't know if they had honors or what (Shanice).

> I think I had to actually take some type of test when I was in third grade to get into the TAG program for elementary school. I think in middle school, because of my grades or something like that, I might have been in TAG there (Michael).

> I was in the accelerated track. Once they gave the South Carolina PAT tests, I think in the third or fourth grade, and they figured out like how smart you are, I was always in the honors classes, or what we called them in South Carolina, the accelerated classes. There was accelerated, and then the normal, and then the slow class. And I was always in the accelerated class. Even up into sixth grade, accelerated just wasn't enough (David).

The above data suggest that third grade was a critical year in these students schooling because they were selected in accelerated and GT programs during this year. Placement criteria were generally via performance on a placement test; however, some students were recommended to either take these tests or be admitted to these programs by teachers and/ or parents. By being selected to these programs early in their academic careers, they were given access to a more rigorous mathematics curriculum than their peers in regular classes. This access gave them valuable prerequisite mathematics experiences that prepared them for advanced mathematics coursework in middle and high schools.

Caring Teachers who Fostered Positive Elementary Mathematics Experiences

In these accelerated programs, these high achievers had access to teachers that challenged and motivated them. Hence, it was a rule, although oftentimes unspoken, that they were expected to do challenging and advanced mathematics, and perform at high levels. Many of these teachers worked in partnership with the parents and served as educational role models, mentors and advocates for these students. The parents advocated for them initially, but the teachers encouraged them to enroll in a particular program, take a particular course and/or participate in a particular project, math-related or otherwise once they were in these advanced programs. Teacher encouragement was evident in these students' stories from elementary through high school. In our second interview, Joyce commented about her third grade teacher, Ms. Brown, who had a positive impact on her early success in mathematics.

> ..I think just because she was a black female, and so I think she had a special interest in me as a black female student, and as like the best student in her class. She was the one that- I guess she told my parents and whoever it is to sign me up

> for the Gifted and Talented level, you know... Your teacher would report your score, and then I guess it would get submitted somewhere, some higher authority, by the end of the fourth grade. That was part of being in the advanced math program. We didn't know what we were doing, really, but our teacher was just like "Here's this Continental math league thing. It's just questions. So take it."

When asked how she was able to continue to do well in mathematics, Tennille reveals how several of her elementary and middle school teachers "pushed her" to excel in mathematics and provided her with support when she needed it. This support and encouragement contributed to her love for mathematics.

> There are people along the way that helped. There was the math teacher in the fourth grade. Well, then I got her in the seventh grade and she was still pushing me. And then when I got to eighth grade, the teacher there was still pushing me. Like if I need help and you'd help me and I get it, I'm like oh, now math is great!

Karen recalls an experience in elementary school where her teacher "made her" do extra challenging mathematics problems. Although Karen thought she was not smart enough to handle such extensive mathematics work, after her teacher encouraged her, she realized that she could do the work and actually began to enjoy it.

> …And our teachers expected a lot out of us get on the accelerated track in sixth grade, you had to finish I think 10 packets in a week of different things, and just answering questions and stuff like that. And your teachers ask you to do it. I told my teacher I couldn't do it at first. I was like, No I'm not smart enough to do it. She's like: <u>yes you are</u>! I'm like, No I'm really, really not. She's like, yes you are. So she made me do it and I did it- yeah, it was no problem, but I didn't think I could [do them] at first.

Once these students were placed in these gifted and talented tracks in elementary school, these caring teachers exposed them to challenging and engaging mathematics coursework, activities and competitions that cultivated their interest in the subject. Many of them talked about liking math, or being good at it, as motivators for them staying in the pipeline. This interest seemed to be enhanced by the instruction they received in their

classes. They were also becoming aware of the discrepancies between what they were learning in their classrooms versus what other students were being expected to do in the "regular" mathematics programs. They perceived that the mathematics that they were exposed to was more challenging than the mathematics taught in the classes of their peers in non- gifted and talented mathematics courses. As Tennille shared about her third grade mathematics class, she revealed how she began to recognize her mathematics skills and talents. She talked about specific mathematical experiences that occurred in her accelerated third and forth grade class that gave her insight into her own mathematical talents. Had it not been for these experiences, she may not have realized her mathematical gifts.

> Okay, in third grade we had these challenges where you sort of pass this little toy around and you compete to see who can say their multiplication tables the fastest, or who can come up with the answer? And so, there were three of in the class that were really, really good and we were always competing with each other. So when I got to 4th grade, we were still competing to see who could finish the fastest and get it all right. Of course you gotta get it all right, you can't get anything wrong. And I remember we had this one paper where we had to do our times tables, and I was the first one to finish. And I got it all right. That felt good. But it was easy.

Joyce and Karen also describe how their 4th grade math teacher engaged them in fun mathematics problems and mathematics competitions. These experiences helped shape their enjoyment of the subject and helped them understand mathematical ideas in real-world contexts. Therefore the mathematics she was learning seemed relevant to her life. Joyce explains:

> My fourth grade teacher had us do fun math projects like, you have to plan a trip to California, like a road trip, so you have to figure out like how many miles you can drive per day, and how long it was gonna take, and the time frame. We always did the Dock project, I think we did that in fifth grade and I was always involved in school math competitions.

Similarly, Karen stated:

> I did a lot of math things growing up, and I didn't even realize from like Challenge 24, winning that, and being in Math Talents and stuff like that, all these different math programs I did. And my school won most of the math competitions that they did. And I did participate on a lot of the teams. I enjoyed doing that.

Tina recalls how her teachers constantly demanded more from them and would not only teach abstract mathematics skills, she would integrate "hands-on" and mathematics-related games that stimulated her interests in the subject.

> … They [the teachers] were encouraging. They definitely made the math challenging… They expected more. We would do our general lessons, let's say, in fourth grade [we would] learn the multiplication table. But then it went further. Okay, let's show you some applications. Let's do something hands-on with cups and beads. And now let's play games that really weren't games, you were using multiplication and division [in the] games ... we didn't notice that we were actually learning stuff at the same time, you know? So I guess that's one of the things- that they incorporated other things besides sitting there just memorizing- it was a whole bunch of different aspects of math.

As evident from the above data, he teachers in these accelerated mathematics classrooms required that their students in engage in challenging and stimulating mathematics instruction by integrating hands-on and real world mathematics, competitions and games in their classroom, which enhanced their interest in the subject.

Personal Factors

In their early academic years, there was little evidence to suggest that the participants played a critical role in their own success. However, the participants perceived that they had "no choice" but to follow-through with the paths that their parents and teachers laid out for them. What was common in all of these high achievers experiences was a willingness to live up to the expectations set for them and to comply with academic and social structures set up on their behalf.

In addition, because of the initial interest in mathematics given to them by their fathers and having positive mathematics learning experiences in their accelerated elementary classes, their interest in mathematics grew. In addition, they desired to do well in school to meet the expectations of their parents and teachers because of the success related values instilled in them by their parents.

In summary, during these students' elementary school years, the participants' parents played a significant role in their success in school and specifically mathematics. First, they instilled in their children values such as hard work, the importance of education, giving back to the community and striving for excellence. Several parents advocated for their children to ensure that they would have access to the best schooling possible, which meant that their children were either placed or "guided" into various gifted and talented and accelerated programs. Once they were in these programs, they had caring teachers who provided them with a variety of positive mathematics learning experiences that cultivated their interest in mathematics. Since these students were expected to do well in these programs, they complied with the high expectations demanded of them.

Middle School

The students gave little mention of the significance of middle school in their success in mathematics. The participants did not acknowledge any significant experiences that shaped their decision to persist and succeed in mathematics during middle school. From the student data, participants continued in these accelerated programs that they were apart of since elementary. Hence, the middle school years were a

time when students' job was to remain "on track" and not jeopardize their success and persistence in their advanced programs.

However, once they were in high school, they cited several key factors that impacted their mathematics success and persistence. This was another critical point in their academic lives where decisions were made that shaped their mathematics learning experiences. In the following section, we examine how parents, educational institutions, the community and the students' personal characteristics impacted their success in high school.

Being Propelled to Succeed: The Ongoing Role of Parents, Educational Institutions and the African American Community During Their High School Years

In early schooling, parents imparted a variety of success-related values that shaped their children's early educational experiences and gave them values that were compatible with what the schools expected of them; therefore, this parental influence was instrumental in their early school lives. Their parents also advocated on their children's behalf to insure that they were placed in classes and programs that would best prepare their children for the future. As their children progressed through the educational pipeline, the parents instilled other values that were important to their success. In particular, the parents instilled spiritual and social consciousness. Spiritual and social consciousness is defined as an understanding of themselves a part of a larger African-American community and belief in a higher power that provided a foundation for their success in school mathematics. This spiritual and social consciousness provided the

foundation for their success in school by giving them a way of looking at the world, themselves, mathematics, and school that would equip them for future success.

Although the data suggest that parental advocacy was present in some of the student experiences in high school, this advocacy took on a decreased role as their children progressed through academia. In fact, as we will see later, students began to rely more on themselves, parental encouragement, educational institutional structures (tracking) and a sense of community connection as ways to help them successfully navigate school, particularly in their mathematical journeys.

Spiritual and Social Consciousness

Another key belief that these parents cultivated in their children was a sense of spiritual and/or social consciousness that provided a context for their academic success and gave them a greater reason for achieving in mathematics. Parents insisted that their children participate in religious and/or community programs in order to keep them "grounded." In fact, as will be discussed in the theme of community factors, the students' connection with God and the community gave them a "greater reason" for persisting in mathematics. Thus students consistently said that success was not just a reflection of them; it was a reflection of God and/or the larger African-American community. They saw themselves responsible for not wasting their mathematical talents thereby failing to represent their family and community in positive ways. Karen's comments illustrate the importance of spirituality in her pursuits. She revealed how her religious upbringing shaped her belief in the importance of giving back to her community, which she saw as a responsibility of those who are successful.

> ..They're [my parents] are really for that no child left behind…It shouldn't be your fault that your parent doesn't know the information that can help you.

> They're like why don't I help that parent know that information. ..I think it's because also our Christian background, you're supposed to help others along the way. You're not anybody if you don't help somebody else, if you don't help your neighbor, or help somebody who's fallen. Like, this is what you learn. And I think that's where they get their selflessness from.

David reflects on the role the church had on his staying on the right path. The spiritual foundation instilled in him by his mother and the church kept him from going astray, even during "wild days."

> I never gave her any reason to doubt that I was- any reason to think that I would end up in prison, in jail or anything like that. We always went to church on Sunday. You know, I couldn't- she did not allow me to stray away too far. You know, whatever I did on Saturday night, I had to go to church on Sunday. So even if I went out and hung out until 5 in the morning, I had to wake up and go to church.

Tennille, Michael and Tina express similar experiences in which their parents' departing spiritual and community values that made a positive difference in their academic accomplishments. These values would prove beneficial to theses students, particularly during times of academic struggles. Instilling this strong spiritual foundation would also keep them grounded and, as we will see latter, was a pervasive source of motivation to persist in a challenging discipline like mathematics.

Many of the students saw their mathematics talent as a divine gift. Hence, they saw themselves as responsible for not wasting their mathematical talents or failing to "represent" their family and communities in positive ways. This consciousness also instilled a belief in a power greater than themselves (God and the Community) for which they were responsible to which better enabled them to overcome obstacles, believe that their abilities, and see their success as a reflection of a divine gift. When asked why she

persisted in mathematics in the face of the challenges and struggles, Joyce states emphatically:

> 'Cause I really think that I owe it to myself, because I'm- it's a talent that I have, it's a talent that not everybody is blessed with, and it's something that I'm definitely interested in. And so I think, with all of that said, it doesn't make sense for me to pursue anything else.

In David's case, his decision to be a policy analysis was driven by watching his mother and others in the community mismanage their money. He believed that they were ill-informed about money and the consequences of spending their money unwisely. As the following narrative reveals, he believed his understanding of financial policies and their impact on people in his community would allow him to better serve his people.

> I've learned what not to do [with money] from them [my family]. My decision to be a policy analyst was enhanced a lot by my childhood. I always felt like we could do a lot better, but I think at a certain point I realized that it was something that was engrained in them, just bad habits. And they didn't know any better. And so if I could get into a position to unteach some of these things, then that would make me feel a lot better. You know, because it's really bad. Just to get money, just to throw it away. It's horrible, it's a horrible- these are educated people, mind you. And but when it comes to money, they're not very educated.

Again we see how parental influence shows up by the parents' insistence that their children participate in spiritual and social activities and giving back to the community. By giving students spiritual and social foundation, they instilled in their children a since of spiritual connection and social responsibility that served them in their trajectory through the mathematics pipeline. As will be discussed later, this foundation served them well particularly during difficult times and overcoming the academic and social challenges they faced during their schooling. In addition, they had a value of giving back to others in important ways, and this giving back took on many forms such as participating in peer mentoring and being a peer role model for other students.

Parental Support and Encouragement

As seen from previous data, the parents provided their children with support, encouragement and that played a dominated role in the participants' pre-school and early educational experiences. In these participants' high school years, parental support and encouragement continued and took on the form of providing the participants with verbal encouragement and support, particularly during challenging times.

The following quotes reflect ways that the parents provided general support for their children. This support was particularly influential when they were considering taking on a challenge or pursuing advanced mathematics coursework. Tina recalls how her parents gave her general support to reach her academic goals.

> They just encouraged me, like, in general. Just like, "Try your best, and whatever comes out of it, you know, as least you can say you tried your best." That's like how I approach every area now. So, they didn't really say "Go into math. You have to do that." But I chose math, and they were like "That's good. As along as that's what you want to do we support you and just try your best."

When it came to her pursuit of mathematics, Anita's mom gave her useful advice that shaped her decision to take advanced mathematics coursework.

> My mother was like, just try it. … It doesn't really hurt to try it. She was just like you don't even have to take all honors classes. Just try a couple of them. So I took A-level science or whatever, and I think I took honors math. She was like Just try it out- if you don't like it, if you can't handle it, then you can always go back. … You're not a failure unless you don't even try…So she's always reinforced that idea with me. So, after I tried it wasn't that bad.

Shanice shares several ways that her parent's encouraged her to do well in school and specifically mathematics. First, Shanice shares how her parents "pushing her" was instrumental in her success. In fact she acknowledges that if her parents had not been as

diligent about her educational pursuits, she may have opted to do activities that were not as academically enriching.

> …If you don't have your parents pushing you to do it, you're not going to because you don't want to. You feel like you have better things to do. ... That wasn't the experience that I had, because my parents always cared. So I cared, because my parents cared. But if I didn't have somebody like pushing me to do well, then would I really have [done well]? Probably not! Because all I really wanted to do was go play, and not do my homework.

Shanice also mentions how other students' failure to be encouraged by their parents has negative consequences on their academic progress and acknowledges the value of having supportive parents. She admits that if it had not been for this support and encouragement she received from her mom, she may not be as successful as she is today.

> If they're [other African-American students] are not encouraged by their family and other people to do well, they wont. You know? …so if you don't have the encouragement from your family and stuff, then it is more difficult to be successful. I mean, if I didn't have the encouragement, I wouldn't be here. I wouldn't feel the need to really excel in school when I was younger, if I didn't have somebody who cared. Like, my mom cared if I got a C grade. If I got a C, she would be really angry. It helps- not just to have the encouragement, but somebody who cares about what you're doing.

Finally, Shanice recalls her parents being particularly interested in her achievements in science and mathematics in high school.

> Well, my parents were always really excited when I got good grades, stuff like that. And they would always be happy if I did well in math and science, I guess, probably because minorities and women don't really do that well in math and science, so like they were excited for that. And if I had an interest in math or science, then they would like encourage me to pursue it because of the fact that, you know, I'm doing well in it. I was just always really encouraged when I got good grades and stuff.

Other participants shared similar experiences of parental encouragement which they credit as having a strong impact on their success and persistence in mathematics

through high school. Karen recalls how her mom always encouraged her to be in a technical field:

> My mother always wanted me to be an engineer, so I think she was supportive of me being within a technical field…. I think her presence in the house when I was younger contributed to the way I grew up [being successful in mathematics].

In addition to their parents being supportive, several participants candidly discussed how their parents and other family members expected them to bring home excellent grades and did not tolerate mediocre performance. This was particularly pervasive in their high school years. Tennille was expected to do well in school by not only her aunt, but other members of her family as well. She discussed how her uncle expected to bring home the best grades possible. Earning an A grade was not enough; she was expected to earn the highest A possible.

> …I'm not saying that we're perfect or that we're going to be perfect, but failure is not allowed. I had an uncle that, before he died, if I got straight A's, and say they were all like 95, well that gives you straight A's, right? That's not good enough! If you got a 95, you can get a 96. If you get a 96, you can get a 97. If you get a 97, you can get a 98. If you get a 100, you can probably still do better. That's the argument. I'm like, all right. It's never good enough.

In a subsequent interview Karen describes how her parents expected her to get A's in her classes and getting B's was not sufficient.

> … And that's what my parents always told us, we expect you to try your hardest and do your best. So my best was getting A's- it wasn't getting B's. And my parents knew that. Like, they knew that if I came home with a B, it was always first, well, could you have done better?

When David's performance in school declined, his mother assumed that the work was extremely tough and never considered that her son was not applying himself. She believed that her son would eventually understand the material and improve his grades because she believed in her son's abilities.

> My mother thought that I was exceptional. You know, no matter what clothes I had on, or no matter what grades I made- even when it got to the point when I was making C's, which was abnormal for her- usually it was like all A's and B's. And when I got to 11th grade, and I started making C's and- even when I started making C's, she just assumed that the class was tough. She never assumed that I wasn't getting it. She just assumed, Well maybe this class is really hard, that's why he's making a C.

From David's comments, we see how his mother assumed that he had the academic ability to do well, even when his grades did not reflect this ability. Because his mother thought he was "exceptional," he related to himself the same way. He knew his lack of performance was based on his own lack of effort rather than his inability to understand the material. The belief that he was "exceptional" was reinforced by him and his high school mathematics teacher who continued to place him in advanced courses, even with his average grades. Eventually, David increased his grades and continued to take advanced mathematics classes. His mother's positive beliefs about her son and her high expectations for him set the ground work for his subsequent belief in his own abilities, both in mathematics and other areas.

Not only was there evidence that parents expected excellent performance from their children, some participants discuss ways that their parents expected them to learn more than what was required in their classes. For example, Tina discussed how her father encouraged her to go beyond what the teacher expected them to learn in science class. He encouraged her to do more than what was required to receive a good grade in school; he asked that she extend her knowledge by using other resources as well.

> I just expected so much more of myself, and you know, my parents expected so much more. … If we were reading something in science, and I'm really interested, I'm going to ask my dad about it. He's going to tell me what he knows about it. Or we'll watch the Discovery Channel program about it, besides just doing the minimum and just read this section about a cell, you know?

Several participants expressed that their parents encouraged them and believed in their ability to do well in school and in mathematics. Parents gave these high achievers ongoing verbal encouragement and provided various types of support throughout their academic careers. Particularly, parents communicated that failure was not an option and that they were able to and expected to do well in school. Even when participants did not perform at the levels the parents expect, as in the case of David, there was an underlying belief that their children where capable of high achievement.

Since many of the participants continued in accelerated programs in middle and high schools, parents did not have to advocate for their children as much at they had in their early educational years. However, in Tennille's case, her aunt was forced to redirect her educational plan in high school. Tennille's aunt, upon her leaving middle school, gave her no option but to enter in the science and math program in high school. Although her aunt knew she would make better grades in a lower track program, she insisted that she enroll in this program, which would allow her to move to a higher academic level and enhance her future opportunities. Tennille comments about how her aunt made sure that she received the best possible education available, even if it meant placing her in a high school away from her friends.

> … The neighborhood we lived in was slowly going downhill, so she didn't want me to be in with everybody else. I mean, you came from middle school and you have these really high grades, I don't want you to just go and sit on your butt in high school and really not do anything. And that's what I would've been doing if I'd have just gone and taken all standard courses. She was like, that's not happening. I'm like okay. I'm like, all right, no big deal.

Karen's parents also recognized that by placing their daughter on the highest academic track, she would be better prepared to take advantage of opportunities in the future. Her parents also realized that there were very few African-Americans in these programs and

her dad believed that her presence in these programs, in elementary and high school, would show that African-American students were capable of achieving.

> …They saw that the most successful students graduating from high school were those coming from the honors track and everything like that. So, they put me in whatever accelerated track was, or the highest track was in the county, so that I might be successful. Also because there weren't that many minorities- there were like no minorities in the G and T programs when I was younger. My dad wanted to show that minorities are just as smart as the majority. There were no African-Americans in the G and T program.

These parents seem to share an underlying belief that their child should be challenged to the highest level. They did not want their children just to do well in school, since it was clear that many of them could have done well on lower tracks, less challenging courses, or skirting around harder disciplines; rather, parents purposefully put their children in accelerated programs so that they could become more equipped to deal with challenges. In addition, some parents saw that by advocating for their child, it could open doors for their own and other African-American children.

<u>High School Advanced Placement, Honors and Science and Technology Programs</u>

Once these students finished middle school, their mathematics coursework made them eligible to take honors, gifted and talented (GT), Advanced Placement (AP) courses and science and technology academic programs in high school. The honors, AP and GT mathematics courses required more work and were perceived as more challenging than the regular mathematics courses. Despite the extra work and challenge of the courses, these high achievers continued to take these courses because they were encouraged to do so by their teachers and it was required by the high school programs. Joyce explains the possible differences between her AP mathematics courses and mathematics courses in "lower" track programs. In the AP calculus there are two tracks: AB and BC. Calculus

AB is equivalent to a one semester of college calculus. Calculus BC includes all the topics of AB calculus with additional topics and is equivalent to two semesters of College Calculus (College Board, 2006).

> I don't think it [the honors program] was any different, in terms of the set-up from non-honors courses, but I guess they just kind of went in-depth with the material, and the level of the work was higher. With math courses, of course, the honors math classes would be BC Calc. Whereas most people would be taking, maybe AB or- well there are three levels of honors math, so the highest level is BC Calc, and then there's AB, and then I don't know what was below that. …I was in BC and maybe the assignments were a little different.

Joyce's comments reveal that there were several tracks of mathematics course ranging from the regular course to honors courses and even within the accelerated programs there were different layers of mathematics courses offered. She was in the AB track which was the highest level in the honors program. She admits that the assignments were "a little different," and went more "in-depth" with the material. It can be inferred from her comments that she received a more enriched mathematics curriculum that ultimately gave her an advantage over her colleagues in other programs.

Being tracked in Gifted and Talented (GT) math courses proved to be beneficial for other students as well. In Shanice's case, she admits that since she had been taking accelerated mathematics classes through elementary school, it was only "natural" that she continued to take advanced mathematics courses in high school. Having these mathematics courses "laid out" for her in high school gave her "no choice" but to continue to take more advanced coursework, which seemed to require little decision making on her part.

> When I was in elementary school, I was in GT math. In the fourth and fifth grade you're in GT math. And then in middle school, I finished geometry in 8th grade. So then, the next step is Algebra II, and then pre-Calculus and then calculus and

> then calc II. So it's just like a track I was on since I was like 9. So, it's just like I continued to take math all the way through, you know?

Since Michael was in the science and technology program in his high school, he was required to take mathematics course through calculus. He was also advised to take the highest level of mathematics that his school offered, which was the BC calculus. As a student in this program, he was encouraged to take advanced mathematics coursework beyond the mathematics requirements to obtain his high school diploma. This exposure gave him the necessary content knowledge and mathematics skills he needed to pursue science and mathematics related disciplines in college.

> In high school at Crimson High, every year you had to take a math class in the science and tech program. And I started off with geometry, and then I went to algebra 2/trig, which they thought me one semester double period, and then I took pre-Cal AP, which although pre-Cal is pre-Calc, they had two pre-Calculus- one that's AB and one that's BC. I was able to get into a BC Calc which, from there you went straight into AP Calc BC. But if you were in pre-Calc AB, you either had a choice to go into AP Calc BC or AP Calc AB.

Tennille, who was also in a science and technology program, was required to take advanced mathematics classes and she took Calculus III in high school. In fact, she was eligible to take Differential Equations (DE) but choose to attend a local community college instead. This experience allowed her to take advanced computer programming classes that she admits were more challenging than course she had taken in her current university.

Because these elite programs had a structured program track of mathematics courses, these students perceived their taking these higher level courses as mandatory in order to remain in these programs. Hence, by being in these structured programs, they believed that they had "no choice" but to take advanced mathematics courses and

participate in mathematics related activities. Many of them just kind of moved through the next math course. There was no "real decision" on their part to take more advance mathematics; they just followed the program's structure or a teacher's recommendation, even if they did not need the advanced courses to graduate from high school.

Caring Teachers with High Expectations: Revisited

Being selected to these accelerated programs in high school gave these students access to a variety of benefits. Most importantly, the teachers in these programs cared about them, held high expectations, and provided them with "good" mathematics experiences that they believed prepared them for the rigors of a mathematics major. In these programs the participants report having skilled and caring teachers that took an active interest in their learning and challenged them to do more than what was expected in the "regular" classes. Teachers provided ongoing support, encouragement, and "kick" that they needed to be successful.

In Anita's case, she had a guidance counselor who recommended that she register for honors classes, and Anita complied with the counselor's recommendation. Anita trusted the counselor's advice, and this lead to her taking accelerated math and English courses. Without the counselor's encouragement, Anita may never have considered such an option.

> My guidance counselor was like well you did pretty well in this, do you want to take the honors classes? Even I was like maybe I shouldn't do it. I had friends in the 9th grade and everything, and my guidance counselor was like maybe you should look into the honors courses. I was just like, eehh… She basically just took it out of my hands. She was like; you're doing too well in this class to stay at the same level. And a lot of my teachers did that for me and for other students. Well I'd rather take the honors class or something like that. Or, I'd rather take the A-level class, cause it's just too much work. They'd just be like, well, no. You're going to take this. They just basically took it out of your hands.

In the above quote, Anita uses phrases such as “it was out of my hands” to describe her experience with the guidance counselor. She demonstrated some resistance; however, the counselor’s insistence that she enroll in these courses overrode Anita’s own reluctance to take these more challenging courses. Again, the theme of adults advocating for the participants is demonstrated. Because of this advocacy, students perceived that they had “no choice” but to follow the path given to them.

This theme also played out in Joyce’s and Tina’s stories. In these cases, African-American female mathematics teachers took an interest in their mathematics learning and mentored them. Both young women speculated that these teachers' interest in them may have been motivated by their common experiences as African-American women. Joyce admits that she did not find as much support from the white male teachers she encountered.

> I had teachers who thought I was so smart, I needed to stay in math and I needed to do well. And they were in general women… She [my African-American female math teacher] noticed my ability. And I talked to her, maybe three months ago about that, and she was just like, “You were just so sharp and you didn’t see it”. And so, when you have people like that who are willing to just support you. She’s a woman, so. And I think that’s what it was, whatever, because- she has always been a person, she [my teacher] wanted to educate all people.

Tina’s overall impression of her high school teachers can be summed up as follows:

> I mean, you know high school. To me, everyone’s always supportive. But in college, that’s when- high school to college is definitely different. In high school, everyone wants you to succeed and do well. And they’re always, yeah you can do it!

Karen expressed similar experiences stating that “What kept me going were the certain teachers who always came and got me and were like “Look, you can do this.” Having teachers who believed in their ability was significant to their success in the mathematics pipeline.

In David's case, this encouragement took a more critical role and a caring teacher's support and encouragement was essential to him taking advanced mathematics coursework in high school. In fact, this teacher served as a key advocate for David. Unlike the other high achievers in this study who had parental advocacy throughout their school careers and were apart of some structured academic program that required them to take higher level mathematics coursework, David did not have these support structures.

David's parents got divorced, and his mother was forced to provide for a family as a single mother. Hence, his mom had little time to advocate on his behalf or supervise him at home. As a result, David admits that he did not perform as well in his mathematics courses as he could have and relied heavily on a caring and supportive mathematics teacher's motivation to keep him in the pipeline. His high school mathematics teacher served as his educational advocate. Speaking about experiences that stood out in his mind as having a great impact on his success, he revealed how the support of his teacher was vital lifeline in his educational life.

> So this teacher just- Motivated me, she always talked to me after class. [She would say that] everyone can leave except David. I need to speak with David. Because a lot of times I got to class and I slept. I would get to class and I slept in class, and she didn't, she didn't let me go. You know, she still motivated me and encouraged me. …And so, I think she just didn't wanna see me fall by the wayside. I frustrated her a lot because she just couldn't understand why I didn't put much effort into it [my math class], but at the time I wasn't real motivated. I didn't know what I was going to do. So at the time, I wasn't the same person I am now, basically.

He continues to speak about some to the specific actions this teacher took to keep him from falling by the mathematical wayside:

> So she [my teacher] was like, well we're going <u>to put you</u> in pre-Cal. I was like, Okay, I didn't care. I'll take it, I'll pass it. And then 11th grade, it was like, Well what are you going to do next year? You know, what are you going to be in study hall? We're going to put you in Differential Calculus. I was like; I don't

> want to take that. But they put it on my [registration] card anyway. You know, it was one of those things where, they saw that I had enough talent to be in that class. And they put me in the class, I think probably because they enjoyed teaching me. I think that had a lot to do with it….Because it kept me on the calculus track. When I took pre-cal, I had no intention of taking differential calculus. I didn't really want to.

Evident from the above data, David's teacher took intrusive actions to insure that he remain on the "right" academic track, which she believed was requiring him to take all of the upper-level mathematics courses offered in the school. She did more than simply encourage him to do well in the classes he took with her; she insisted that he take advanced mathematics courses, even when his grades were not reflective of the mathematics talent she believed he possessed. She saw his mathematical talent, and "she enjoyed teaching" him. Because he saw her as an advocate who had his best interests, he followed her advice. This type of teacher advocacy served to help push David and a few other participants through the mathematics pipeline at times where their parents or the students themselves may not have chosen to persist.

Peer Influence in High School

Finally, in these accelerated programs, peers played a significant role in their success and persistence in mathematics. Since there were few other African-American students in these accelerated classes, they created academic and social support structures in these classes, which provided peer motivation and encouragement. In addition, their peers highly motivated which allowed for more effective teaching than was perceived in regular classes. Many of these students formed friendships with these like minded students, which provided another layer of support. In the following vignette, Joyce reveals how being in classes with other motivated students helped the teacher be more effective in her classroom instruction.

> I do know necessarily if their instruction in honors classes was that good, but just the quality of students that were in them….Because in honors courses, you generally get kids who are excited about the material, and you don't have behavioral problems. And so I think with that, the teachers were better able to utilize their time and bring in special topics or have special activities that they wouldn't be able to have in non-honors courses where students aren't engaged by the material. And so, I don't think it was necessarily the teachers themselves that made the honors classes so great. Because, if it was the teachers themselves, then they could have made the non-honors classes great too.

As Joyce's comments illustrates, the peers in her class were instrumental in the quality of those classes. She acknowledges that a major difference between her advanced classes and the "average" classes was the students. The students' motivation and drive, in her opinion, impacted the teacher's ability to engage students in challenging and engaging mathematics.

Shanice also reveals how being in classes with like minded students had a positive impact on her success in mathematics classes.

> Well, I feel like if you're in a GT class, you care. Like when I was in twelfth grade, I was taking Calc II, and our teacher didn't really- he gave A's and B's… Because if you're in twelfth grade, and you're taking Calc II, then it's obvious that you care, you [are] meant to be there, and you work hard, you're trying- you do well in math and you understand math. …The students are there deliberately. They try to work hard, they try to understand; they want to be there…. Whereas regular students…they have to go to school because it's the law. Their mom makes them go. Not like all of them, but I'm just saying that would be a basic difference between a GT student and a regular student.

Because she was in a class with other motivated students, Shanice's instructor would "give the class over to them." She enjoyed the independence that she and her classmates experienced in this class. The teacher allowed them to work together to solve problems because he trusted them and believed that could do the work. In these cooperative groups, she became more confident in her ability to solve problems.

> I think that if he [the math teacher] had been like the other teacher, it maybe wouldn't have been as helpful to us because we liked having the class to

> ourselves. Like we liked talking to each other, figuring it out ourselves, stuff like that. So it was better that way, in that we were more independent in figuring out stuff for ourselves. And we liked teaching it to each other.

Finally, Anita moved from a predominately black school district to a predominately white school district and comments about the people she encountered in both school districts. She admits that socialized with the same type of students, which were other high ability students or what she refers to as "nerds." These students were viewed as a source of support for her in both school settings. She explained:

> I think the major difference was just being in a class and being like "Wow there's only one other black person in the class." I think that was just the major difference. Like the people really were the same. Like I basically hung out with the same type of people when I was in middle school that I did in high school, and they were basically the ones that you know, I guess, like the nerds basically were the people that I hung out with. The people who actually wanted to do well, and actually did do well in school…So they were the same type of people… they were equally supportive as my friends that were in middle school.

The types of people Anita associated seemed to value education in the same ways she did. Since they shared these values, they did well in school and were a source of support for each other. This peer support was valuable to her and other participants in the study.

Developing Social Consciousness: Where are the others?

These high achievers participated in accelerated academic programs throughout their school careers. These programs provided opportunities for them to be exposed to accelerated mathematics coursework, caring and motivated teachers and positive peer support. Although the majority of the participants went to integrated schools, many of their honors and advanced placement classes had very few African-American students. The majority of African-American students were regulated to "regular," or what one student referred to as "substandard," classes. These "regular students" did not have access

to the same type of knowledge that these high achieving students did. It became clear to many of the participants that they were among a limited number of minorities that were allowed access to these programs, and several of the participants were becoming disheartened by this reality. Consequently, they were beginning to see themselves inside of a larger societal context. This awareness caused them to see their success in their mathematics courses as a positive statement to the larger community and other African-American students. This growing social consciousness provided another layer of motivation as they moved through the mathematics pipeline.

As Anita comments reveals, realizing the racial disparities between the honors classes and the regular classes was disheartening.

> Yeah. I had to get used to it [being the only African-American]. Especially taking the honors courses, like, there weren't too many African Americans, or minorities period, in the honors courses. And I remember like in senior year, I was so upset one day, because my English teacher was like, Maybe you should like consider going to a certain school for college and everything like that- and I want you to talk to this other teacher who has the information about it and everything. And I was like, Okay. So I left my classroom for a little while to go to her classroom. And it was like an A-level class or whatever. Almost all of the students in that class were minorities. And it just clicked. Something clicked for me. I was like, Why in the world am I in a class where I can count how many black people are in the class on my hand, while this class is full of mostly minorities? And I was just like, why is that?

Tennille, while discussing her high school mathematics courses, makes a similar observation about the racial divide that existed in her science and technology program. "It's a math, science, computer science program. That's what it's geared to, and it's a mixed school, but in the magnet program, the majority of the people are white people."

When asked in what classes where the African-American students. She replied: “They were in the standard classes. All of my friends- when I went to the magnet program, all of my friends stayed in the standard classes. That seemed strange to me.”

Anita comments about the difference between the honors classes in the predominately Black school versus the honors classes in the predominately white school district that she attended.

> I think the major difference was just being in a class and being like “Wow there’s only one other black person in the class.” I think that was just the major difference. Like the people really were the same. I basically hung out with the same type of people when I was in middle school that I did in high school.

She latter comments about how this difference opened her eyes to the inequities of the school system.

> And I remember like my senior year, I was so upset one day, because my English teacher was like, maybe you should like consider going to college. I want you to talk to this other teacher who has the information about it and everything. And I was like, Okay. So I left my classroom for a little while to go to her classroom. And it was like an A-level class or whatever. Almost all of the students in that class were minorities. And it just- it like clicked. Something clicked for me. I was like, Why in the world am I in a class where I can count how many black people are in the class on my hand, while this class is full of mostly minorities? And I was just like, why is that?

Being aware of the racial disparities in their accelerated tracks was a catalyst for a level of social consciousness and created some challenges for several participants. Some students reported that some teachers held negative perceptions of African-American students. For example, Karen Johnson revealed an incident with at high school Calculus teacher who she perceived as being particularly hard on her and other African-Americans in the class. Up until this class, she had a 4.0 GPA which put her in the running for being the valedictorian of her class. In this particular class, she received a grade of B even though her overall average in the course was 89.5. This B grade caused her not to be the

valedictorian of the class, and she believes that this teacher's attitude could have been racially motivated.

> When I first got the B [on the first test], I was like Oh I don't like the way this is going. And he was already like a difficult type of teacher or whatever, because hard on us. Hard on us in particular, and kind of like would talk down to me and my friend. And he would talk down to some of the other girls, too, especially me and my friend.

When asked what she meant by "talking down to her and her friend," she replied:

> I mean, just the way he would answer our questions. He never would look at us in the face, and I think he never would look at us in the face when we asked him a question, and he would always make you feel like your questions were stupid. But, in the end, I mean, he's just like that with people who he's intimidated by, in general.

Although this experience was not common to many of the students, Karen's comments reveal one way racial disparities impacted their educational experiences. Although more subtle, the experiences of these high achieving students reflect the impact of being an African-American high achiever.

The Church and Spirituality

Many of the parents instilled spiritual values in early in their children's lives and required them to attend church. When these students got older, they continued to participate in church related activities and cultivate their growing spiritual identity. There was discussion from David, Karen and Joyce's stories demonstrate how they had a desire to give back to their community through their activities in the church. For example, Karen demonstrates how being a part of a church family allowed her to be a positive role model for children in her church. She believes that this is her responsibility as a person who has been blessed with gifts and advantages.

> ..'Cause when I go back home to church, I try to help out my friends who've graduated from college, to set up other tutoring programs at our church. To let

> kids know, don't be scared of math you can do it. And if things are hard, I'll help you, you know. You can have my email address; you can have this, as long as you work hard and try. A lot of kids looked up to me at church because they see me as all right because I did sports. I wasn't just a nerd or whatever. I was popular when I was in school.

Joyce and also expressed how the church supported them during youth. Joyce recalls:

…I've had huge support from my church, like from my youth group. …I was very active in my church's youth groups, so I built friends through it. And I just think that any opportunity that allows you to make friends with people, like it helps your self-esteem, you know, you feel more confident, um, you just feel more comfortable with yourself. So, in that sense, it probably helped my development.

David expressed similar sentiments:

…We always went to church on Sunday. You know, I couldn't- she did not allow me to stray away too far. You know, whatever I did on Saturday night, I had to go to church on Sunday. So even if I went out and hung out until 5 in the morning, I had to wake up and go to church. …And church kind of gave me that foundation, where I knew what was right or wrong. Even when I was out in high school doing wrong, in the back of my head, I knew it was wrong. You know, even- you know, I was hanging out, lying to my mom, like Oh yeah, I'm at this place, and I'm at some other place. I knew it was wrong. And I had a conscience…It wasn't one of those things where I was a cold-blooded type person.

Being apart of a church community gave several of these participants a spiritually foundation and community structure that enhanced their overall self-esteem, provided them with a focus that kept them out of trouble, as in David's case, and allowed them to connect with the larger African-American community and their peers. This foundation was instrumental in given them a sense of accountability to something outside of themselves. In college, they began to rely more heavily on their spirituality to help them overcome various challenges they faced in and outside of the mathematics classroom.

Personal Characteristics in High School

In the earlier stages of their personal and academic development, the students did what was expected of them with little resistance. There was also a budding interest in

mathematics that was cultivated by positive mathematics experiences in elementary school. However, during their high school years, the students own role in their persistence in mathematics became more evident. The student's role in their success and persistence in mathematics can be characterized in three major ways. They demonstrated an attitude of compliance, enjoyed mathematics, and began to consider future careers in science, engineering and mathematics-related fields. These personal characteristics served as motivating forces that impacted their persistence and success in the discipline.

Attitude of Compliance

First, the students perceived that they had not choice but to abide by pre-designed high school programs outline in their honors, AP and Science and Technology programs. This attitude of compliance was manifested in their choice to comply with the parental support structures, mathematics course sequences and church activities that were given to them. It was as if the students were being "pulled toward" a certain academic pathway and they did not have much say in the matter. Tennille talks about how she never even considered dropping out of the magnet program that her aunt insisted that she attend. When asked if she ever considered moving into a program that required less rigorous mathematics course work, she explained:

> In my household it's like, what else are you going to do? You're going to school. You're getting up and you're going to school every morning, and you're not bringing home any old kind of grades. You didn't do it in elementary school, you didn't do it middle school, so don't start in high school. Well, what would've been the good excuse for stepping out of the magnet program? There's no good excuse. Like, what are you going to argue- I don't like to study? Well, that's too bad- people don't like to do a lot of things, but they do them anyway. So there was really no option there.

When asked whether or not she could choose to remain in the magnet program once she began to experience challenges in her mathematics courses, Tennille spoke frankly about why she "had to" stay in advanced mathematics despite the challenges she faced:

> I looked at 9th grade year. I wasn't looking far ahead to what I had to do. And I didn't do that when I got to college. Well, I have no choice! I mean, well for me, I ended up in math. And to succeed in math, you really don't have a choice. I mean, you can choose to go against it, and you're going to fail!

Because of the expectations and values her aunt ingrained in her, Tennille perceived that there was "no real option" but to follow through in the magnet program, whether she wanted to or not. Also, she perceived mathematics as a discipline that required "no opting out," meaning that one simply must continue in the subject no matter what or risk failure. This theme of "no choice" was also pervasive in other participants' stories. Tina, whose mother was an educator, expressed similar sentiments as she talks about her reasons for persisting and being successful in mathematics. "One thing [that kept me being successful was] my mom, being an educator, I had no choice," she comments.

The above data reveals that these high achievers perceived that they had "no choice" but to comply with their parents, teachers and others expectations of them. In their worlds, they did not see their success and persistence in mathematics as a "decision" that they made themselves; being successful was a decision that was made for them. They merely did what was required of them in order to meet the expectations that were handed down from these significant adult figures, which was a key factor in their success in mathematics. However, their willingness to comply with the expectations of others created an opportunity to explore higher level mathematics and allowed them to develop

a love for the subject, which would prove vital to their success in advanced mathematics courses in high school and college.

I like Math and I am good at it

While these high achievers were being guided along these academic pathways that required them to take extensive mathematics coursework, they deepened their interest in the subject. In their early years, their fathers initiated an interest in mathematics. In high school this interest was further developed and nurtured by their experiences with caring teachers. This "evolving fondness" for mathematics was becoming a part of their academic identities; however, not all of the participants were aware of when or how this liking began nor could they always articulate specifically why they enjoyed the subject. What was most common, however, was an overall enjoyment of the subject matter and the challenges and triumphs that it brought them. Anita recollects on her love for mathematics.

> Well, I've always liked math. It has always, like, sort of come pretty easily to me. Well till I got to college and I had to work for it. (Laughter) But it came pretty easily to me, and I was in like Algebra and everything when I was in middle school, and then I entered into Algebra II and Trig [in high school] I didn't know to be able to take the Calculus course when I got to senior year. [In order to take Calculus senior year] I would have to double up on my math, until I got into junior year and it was too late by then. So I just decided to like stop at pre-calculus because that's all I could do.

Joyce felt that besides having positive school experiences, her enjoyment of mathematics was instrumental to her success and persistence in the discipline. In fact she credits this like for mathematics as being a key component to her achievement in the subject. When asked why she persisted in mathematics, she replied:

> Probably the school experiences [had a major impact on my success]. Like, just in going to school, I just figured out that I liked math. And it wasn't anything that

> my parents did- well, my mom always used to say that I should be an engineer, but I never took her serious.

Tina shares her love for mathematics: “I loved math and science in elementary, middle, and high school. And I did well in all of those classes.” After completing all of the basic requirements for her high school diploma, Anita’s decision to take an advanced mathematics was fueled by her enjoyment of the subject. “I just made sure I got those [prerequisite courses] out of the way, and then I was like I kind of like math, so maybe I should take pre-Calc as well.”

In addition to developing a love for the subject, they also knew that they were good in mathematics and had a unique ability to understand the subject. In high school the students experienced few mathematics related academic challenges. Although their mathematically experiences were not without a few “rough spots,” they did very well in their mathematics courses and overcame many of their academic challenges they faced. There was little discussion of the mathematics in high school being particularly overwhelming or difficult, even though they were taking accelerated and AP courses. They realized that their mathematics courses were more challenging than those of their lower tracked peers; however, they still saw the mathematics as something they could do with relative ease. In high school, they believed in their abilities in mathematics and had an overall positive attitude about their ability to do math. It was not until college, particularly in their more theoretical mathematics classes, that they began to relate to mathematics as “hard,” and therefore relied more heavily on their own self-efficacy and the support of faculty and peers to overcome their academic challenges.

College Scholarship Programs: Providing Faculty and Peer Support which Impacted Their Success in College Mathematics

The final phase of these students' academic trajectories was their experiences in post secondary institutions. All of these high achieving students were a part of a structured or loosely-structured scholarship program. Structured scholarship programs are defined as those programs that contained mandatory requirements, other than maintaining a particular grade point average, for which students had to satisfy in order to remain in the program. In some cases, students had to engage in these activities as a cohort. For example, the Sterling Scholarship Program, an elite science-based academically competitive scholarship program, required students to participate in a summer bridge program, study group sessions, internships and mentoring programs in addition to maintaining a 3.0 GPA. Students in this program had no choice but to participate in these academic and social enrichment programs in order to remain a Sterling Scholar and continue receiving their academic scholarships.

Loosely structure scholarship programs are defined as programs that provided optional or strongly recommended programs within a financial support structure. Although participation in these optional programs and activities was not a requirement for their scholarships, students were strongly advised to participate in various peer support groups, internships, research experiences, and other academic and professional programs. An example of this type of program in one university's curriculum-based honors program that required its students to maintain a 3.0 GPA without requiring them to participate in other programs and activities in order to keep their financial awards. There was an emphasis, however, on the importance of these activities and students were

strongly encouraged to engage in academic and social enrichment programs and activities.

What was similar about both the structured and loosely structured scholarship programs was that it allowed students access to one or more of the following support services: financial support, peer and faculty mentoring opportunities, study groups/peer support, summer bridge programs, and program staff support. In addition, within these formal support structures, students participated in a several internships, attended professional programs and conferences, and participated in student-based mentoring programs. Access to these support structures, particularly peer support, was instrumental to these students' success as mathematics majors. In the remainder of this section, I will highlight the ways in which these programs provided essential support for these students and how the participants perceived the impact of the various support structures that were available to them.

Declaring Mathematics as a Major

One of the more interesting findings from the college data was that none of these students initially declared majors in mathematics. All of the students initially enrolled in college as declared majors in other science, engineering and mathematics related disciplines or education. After becoming dissatisfied with these initial majors, they began to seek out other options for a major. Because of their access to various faculty members through their scholarship programs, many of the students (six out of eight) discussed their dissatisfaction with a faculty member and were encouraged to investigate a possible major in mathematics. Thus, by virtue of being apart of these programs, students had access to faculty mentors who gave them essential information that impacted their

becoming mathematics majors. Before seeking help from faculty, many of them were not clear about what one could do with a major in mathematics except teach or be an accountant.

Initially several participants believed that a major in mathematics would be limiting; however, their interaction with faculty helped them understand the vast opportunities available to mathematics majors. In fact, several participants revealed that mathematics was an attractive major because it "kept their options open" and would allow them to remain in a SEM related careers without restriction. A mathematics major was viewed as a sort of liberal arts major in the sciences and quantitative disciplines because it allowed them to stay true to their interests in SEM related fields while not committing to one course of study.

This pattern is illustrated by Michael who became dissatisfied with his initial major in biochemistry. A faculty member was instrumental in his decision to major in mathematics because he made Michael aware of the some of the benefits of this major. From this interaction, Michael saw how majoring in mathematics could provide him with several future opportunities by keeping his options open to a variety of science and mathematics related careers.

> I actually came across my Calculus II professor, and I was talking about how I wanted to drop the biochemistry major. I wasn't sure what I wanted to do, because I didn't like chemistry. I didn't like biology. So he was talking to me a little bit about mathematics and about some of the benefits and aspects of [mathematics] - the difference between applied and pure mathematics and [how] you could go into any area you want to [with mathematics], so you have the freedom that can be applied to any technical field. So, that kind of interested me in wanting to math, 'cause I want to make sure I'm well-rounded and make sure I have my options open to where I want to go. 'Cause I'm not sure exactly what I want to do, but I have an idea of what I want to do.

Tina shared a similar experience. She was also had become dissatisfied with her major in chemical engineering after her freshman year. She worked as a tutor in the Upward Bound Program the summer after her freshman year and enjoyed the experience. She was not yet clear about an alternative major, which lead her to talk with a white female mathematics professor that she admired and respected. The conversation with this faculty member solidified her decision to major in mathematics:

> …After freshman year, I was like Okay I don't want to be a chemical engineer. And then I looked to see what other [than] engineering, our school offered, and [they offered] only computer engineering and electrical engineering. … After talking to people, about what you can do with your math career. .. I really was thinking about becoming a civil engineer. And our school doesn't have it. So I was like, what can I do that might let me eventually become a civil engineer. And after talking with people, that's when it was like- Oh, math will lead you into so many different things. So that helped me, you know, decide okay, I'm going to be a math major.

When asked were some of the people she spoke to were, she responded*:*

> .. I have a mentor in the math department. She's a woman. She doesn't have her PhD, but she's awesome… She's like the best teacher there. And I always- if I have any questions, I talk to her. … So, after talking to her too, and I shared my experiences with Upward Bound with her, she was like, Well you sound like you really want to make the change [to being a mathematics major]. And she went through, like, this is what you're going to have to do, and blah blah blah. And so that- sophomore year, I was like Hey I'm going to be a math major!

The conversation she had with the faculty mentor and her experiences in the Upward Bound program solidified her decision to major in mathematics.

David, Anita, Tennille, Karen and Joyce also choose a mathematics major after similar conversations with faculty and other key people. After becoming dissatisfied with their initial SEM major, they choose a mathematics major after learning about the opportunities available in mathematics from a faculty member. All of the students came to college with strong mathematics backgrounds from high school and had the necessary

prior knowledge to major in mathematics. Unfortunately, these high achievers were unaware of the opportunities available as a mathematics major. However, after a freshman or sophomore year exploration period, many of them saw mathematics as a way to remain in science-related disciplines while keeping their options broad enough to give them some flexibility in their future career paths. This was perceived by these students to be one of the major advantages of a mathematics major and played a major role in their decision to major in mathematics.

Switching Gears: The Initial Mathematics Proof Course

Having chosen to major in mathematics and understanding how this choice supported their future goals; these high achievers proceeded to take the necessary college coursework to complete their degrees. Since many of them had taken rigorous mathematics coursework in high school or had taken many of the mathematics prerequisite courses while pursuing other majors, they were familiar with the rigors of mathematics courses and were aware of what it took to do well in these courses. Many of them found their calculus, linear algebra, differential equations and other more to applied courses to be somewhat challenging; nevertheless, these challenges were manageable, and they felt equipped to handle them.

However, in their sophomore or junior year, they took an initial course that was more theoretical, which required them to construct formal deductive arguments or proofs. This was the first time many of the participants were expected to generate a logical mathematical argument, and they felt ill-prepared. Many found the shift from doing procedural driven formulas and applying algorithms to constructing formal mathematical proofs extremely difficult. Some even began to question their decision to major in the

disciple. Several participants spoke candidly about this transition into theoretical mathematics (constructing proofs) and how it impacted their persistence in the discipline. Michael offered that,

> The math program here is more of a theoretical approach to math, so what that means, which is a lot of proofs… to me, it's like hard to grasp those concepts at times. I mean, people like- I can get it, but I just think math is still hard. I get the concepts, but then proving them is a totally different thing. I'm more of an applied [person], just give me the equation, and I can do it

Anita and Tennille share their experiences with their initial proof course. Both acknowledge that this transition into more theoretical mathematics classes was challenging; however, once they both made it over the "hump" they was pleased. During an interview with Anita, she describes what she enjoyed about studying mathematics. Speaking specifically about her experience in an initial proof course and the challenges she faced, she shares how she renewed her love for mathematics and the challenges that studying mathematics brings.

> It [math] was just something that I enjoyed, more so than anything else that I had tried. So, even in 301, like that's the Real Analysis class, and that's like our introduction to proofs class- oh that was so hard for me. I took that last semester, and it was just so difficult for me. And its like, that has to be like the hardest math class. 'Cause it literally took me to the middle of the semester to really understand what was going on in that class. But even then, once I finally did get it, I was just so happy. That was just so great for me to be able to be like, you know, I went into this thinking I was going to fail…But then everything just clicked to me, and I was able to get it, and being able to do the proofs and everything like that. It's like a little puzzle for that class, you know what I mean?

In the following quote, Tennille reflects on her experiences in her first proof class and her initial reaction to the shift from working with numbers to constructing proofs. Similar to Anita, it took Tennille some time to adjust to constructing proofs, and this shift in focus "tore her [mathematical world] apart." However, Tennille learned to adjust to constructing mathematical proofs and rekindled her love for the subject.

> And then the numbers [in the proof course] disappeared. The first course we had to take was Introduction to Logic. He told us that we were given the number 0 and the number 1, and we had to prove that 2, 3, and 4 existed… I'm like, what are you talking about? You just tore my whole world apart ... You can't assume this and you can't assume that. Oh, we're going to have to prove everything! Nothing that I know to be true is really true until I prove it. That wasn't how it worked in high school.

David initially struggled in his first theoretical mathematics course, Introduction to Proofs, and experienced some anxiety while taking this course. Despite experiencing challenges, he did not quit, and sought help from the professor. When the concepts finally "clicked," his admits that math was fun again.

> I was frustrated because it [proofs] was a brand new concept, and I was mainly frustrated because he didn't have any solutions to my problems. So there were a lot of things that weren't going well for me. You don't know if you're getting the homework right or wrong, so how do you correct yourself? You have to go to office hours. And office hours, it was just as quick as in the lectures. You've got so much information, you didn't know what was important; you didn't know what you had to concentrate on. He never put emphasis on anything, everything is just one tone, so it was very frustrating. It was very different from other classes. ….On the first quiz I made a 0/20. The second quiz I made a 10/20. The third quiz, it was just 10/20, 10/20, 8/20, 10/20. Then one day, it was like God just shined the light. It was like 18/20, 17/20, "Good job", you know "Good point", you know? My proof-writing skills just got like a lot better. You know, it [math] was fun again.

Tina explains what she had to endure in order to do well in her theoretical mathematics courses. Her comments vividly articulate the experiences that she and other participants cited as they discussed the challenges of their theoretical mathematics courses. As revealed in this narrative, Tina had to rely on a variety of resources in order to "survive" this theory course:

> For me, in order to do theory [courses], I have to be on this next level of thinking to get some of this stuff. And for me, I'm going to have to sit down, and I might stare at something for an hour, and still be like, what are they saying?? And then I'll go talk to someone else, and they'll be like- I don't get it either. And then, for

> me, it's like the theory, you can't just practice that. You have to read, I have to search on Google, find other sites. I'm looking for different books in the library to explain one thing. I'm doing research just to understand what they're asking. ..That's what makes the theory hard. I gotta go search everywhere in the world to kind of piece together just what they're asking. Now let me use that and apply it to the question. 'Cause the question's not exactly asking you exactly what that just said. So that's going to be another hour trying to figure out how to apply what I just read to the question. So to me, that's what makes that hard. 'Cause if I didn't understand it [the question], I won't be able to answer that question still. So it's like the back-and-forth process. Once I got it, it was worth it.

As evident from the above narratives, several participants report that they were excited when they finally understood how to construct proofs and had experienced a sense of satisfaction at being able to overcome the initial challenges of constructing proofs. They credit being willing to work hard and persevere, having a good transition course designed to orientate them to this "new" way of thinking, and getting both faculty and peer support as their keys to being successful in their theoretical mathematics courses. Specifically, Tina's comments summarize the overall essence of students' experiences in these their theory courses. Her experiences reveal how much work and effort several participants were willing to go through in order to be successful in these theory courses. Despite the work and effort it required to understand theoretical mathematics, they were willing to utilize their resources, persevere and finally experience success in these courses. In many cases, overcoming the challenges was fun and rewarding and actually served as a motivating factor in their persistence in their mathematics courses.

Faculty and Staff Support and Encouragement

By being a part of these structured and loosely structure college scholarship programs, students had access to faculty that provided them with valuable advice and information that initially lead several of these students to major in mathematics. In

addition to providing these students with vital information, some faculty members provided both academic and moral support and encouragement that had a positive impact on their persistence as mathematics majors. In fact, faculty support was a key resource that they used to overcome the challenges of their more theoretical mathematics courses. Anita discussed how several of her professors encouraged her to attend office hours and get support.

> They have office hours. So, you can always do that, or through email. A lot of my professors are very approachable. So they'll tell you, like, you know, on your syllabus they'll have their office hours, like when you can get in touch with them, the best way of contacting them. I've even had professors who give me their home numbers if I've had problems. So like the information is there, all I have to do really is just contact them.

Joyce recalls similar support from faculty:

> My Advanced Calc 1 professor was very nice. I think that definitely positively impacted me. 'Cause you know, I was always at his office hours. It was like a group of us, and we'd all sit around the table, and he'd throw stuff up on the board, and he would just kind of help us like go through them, problems and stuff like that. So that was a positive experience.

While discussing the advantages of being a Sterling Scholar, Anita speaks specifically about the some of the supportive faculty she has encountered by participating in the program. When asked what she likes about the Sterling program, she reveals:

> ..Just talking to them [faculty], and seeing how supportive they are…, I never really had people to support me outside of my family. Just to have other people like say, "I want you to succeed. I want you to do well. And for you to succeed and do well, I'm going to do this, this, and this." That makes me say, well, since they're doing so much for me…. They're really nice. Like most of the people in the math department that I've had so far, are very approachable, and if I need to talk to them, they'll be like well you know, maybe you should check this book out, and everything, and if I need like a recommendation from them, they're really willing to be like you know, I'll write you a really good recommendation and everything like that. So, like, if I have questions I can always go to them and they'll support me.

When asked what specific kind of support they provided her, she talks about a particular incident where a professor went out of his way to assist her and her classmates in her proof course. Anita recalls:

> I've had some teachers, some professors are really, really nice, and they will do that for you. .. I had Dr. Bengal do that for me. He actually called me on it and was like, you're having trouble, you need to come talk to me, you need to like come with questions if you have some. And like I have, for my 302 class now, my professor he was like, you know as a class, you guys aren't doing as well as you should be. So he actually has set aside extra time for us, like you know problem-solving sessions where he'll be there, where we're working on the problems, and he's like- you know, this is a question that you need to ask yourself now to get to the next step. So maybe you should think about it like this, you know what I mean? Like I've had professors who are really really nice, who actually go out of their way to help me.

Faculty support was very instrumental in Tennille's success in college mathematics. Tennille, the only student in the study who attended an HBCU, spoke consistently about how various faculty members supported and encouraged her throughout her college career. These faculty members would not allow her to fail and were available to help her even after she was a student in their courses.

> I had department help. I remember [taking] linear algebra with one of our professors, and he always said to just come to his office. And I needed his help, so I went to his office. So I think that particular semester, I had another professor for D.E. who was awful, and I needed help. So I found out that the professor that taught linear algebra also did very well with D.E. So I spent probably a good 90% of the days that I had school with that professor, doing D.E…. On Thursday, most of us don't have a lot of classes. And the professor that always helped me didn't really teach on Thursday. But I could call him and say, "Okay, are you going to be in your office on Thursday?" "Uh, hadn't planned on it." I'm like, "Well, I really need you to be in your office on Thursday." (laughter) "All right, I'll be in at 1." So we'd go meet somewhere in the math building at 1 and we wouldn't leave till like 5. But that was like a regular every week type deal. We meet almost every day. I did well in the course.

As the above data reveal, faculty support was an important factor in several participants' success in their college mathematics coursework. Particularly, for those

students in the Sterling Scholarship program and Tennille who attended an HBCU, faculty provided both academic support and overall encouragement that helped motivate these high achievers. Participants received support with homework and test preparation and general support and encouragement from faculty, especially minority and female faculty. Although not all participants recall receiving encouragement and support from faculty, there was evidence to suggest that faculty support was influential in many of the participants' college success.

Internships and Attending Professional Conferences

Being apart of scholarship programs allowed them to participate in internships and attend professional conferences. For several participants, participating in internships and attending conferences help provide additional motivation for them to remain in the pipeline. These internship opportunities allowed several participants to get hands-on experiences in a variety of applications of mathematics and gain valuable research experience. Based on his vast internship experiences, Michael was able to gain valuable experience and exposure to the wealth of opportunities available in mathematics. Knowing what he could do with his mathematics degree kept him motivated during challenging times, particularly while taking his more theoretical mathematics courses. He admits that he is more of an "applied" mathematics person, and by participating in several internships he was able to explore a variety of mathematical interests and possible career paths. In addition, he was able to explore mathematical ideas and cultivate his mathematical skills in ways that he was not able to do in his college mathematics courses.

> Well for my summer experiences that I had to actually do a lot of research. After my freshman, sophomore and junior years I did internships…After my freshman year, I did research in England at Lancaster University. Sophomore year I did research at M.I.T and they were doing like robotics and whatnot. And last year, I

> worked- I did research with the F.B.I. These experiences helped me with what exactly I wanted to focus in on in mathematics. …It [doing internships] was hard in a sense, because there were no [mathematical] examples you can go off of. So everything you had to come up with on your own. That was kind of the hard part... I had to actually derive the equation myself.

When asked why these experiences were so instrumental in his persistence in mathematics, he explained:

> Just seeing how [mathematics is used] in my internships and how I can use a math problem to solve the problem was a motivation for me. [The internships] just basically opened my eyes to how use math is applied in different areas.

Tina's internship experiences were also valuable in helping her see how mathematics was used in a variety of fields. These internship experiences helped her solidify her belief that with a major in mathematics, she could do anything, a belief that was a cornerstone to her persistence in mathematics. In addition, because of her internship experiences, she knew that she could engage in "hands-on" activities that interested her.

> I have always liked hands-on type things. And even doing math, people were like Oh you're not going to do that much hands-on. But I'm like, yes I can. Because having internships, like this past summer I worked with astronomy. Never did I think I would use my math with astronomy, which was so cool. Telescopes and things like that.

David also admits that being exposed to internship opportunities through his scholarship program and department helped him understand the various job opportunities in mathematics, which motivated him to stay in mathematics.

> We [in the scholarship program] had a leadership retreat from 9 to 2 and a lot of folks turned out, there were a lot of companies offering internships and employment opportunities, research opportunities… A lot of companies come out like IBM, NASA comes out.. Also, just from being enrolled in our department, and attending a lot of workshops, and a lot of companies coming out and giving examples of what they hire mathematicians to do. And so, I didn't learn until I was- like you said before- exposed to an environment where you're approached

> by different companies, and they're explaining to you what the different careers are. I'm applying at the Census Bureau this summer.

Some students were allowed to attend professional conferences as a part of their scholarship programs. At these conferences, participants were exposed to professionals in mathematics who served as role models for them. Tina and Karen, both Sterling Scholarship recipients, participated in a conference for African-American and other minority females in mathematics, and they found this conference extremely motivational. They describe how being around African-American females who had "made it" in mathematics rejuvenated their interest in and excitement about being in mathematics, which was growing weary because of some of the challenges they had been experiencing in some of their courses. Tina who had just come from this conference a week before our second interview was excited to share her experiences with me. She enthusiastically shared:

> Some regards, like you know, to the point where I've liked everything. Especially after this conference I went to, I gotta tell you about, because it was- it impacted. In finite Possibilities is the name…it was about female minorities in math. .. It was at Spellman. This is the first time I was actually writing stuff down [at a conference]. You know, my ears were wide open. They had women who were getting me like their PHD in mathematics and math ed- [there were also] women who are working for the government, and all different things. Hearing their lives experiences, about schools, what led them to decisions, things they want other women to know that helped them was very inspiring.

Karen, who attended the same conference, shared about how seeing other African-American female mathematicians served as inspiration for her to persevere in mathematics. These successful female mathematicians became role models and women with whom she could identify.

> I recently went to this conference called the Infinite Possibilities Conference, at Spellman College. It was the greatest thing I think I've ever experienced in my life. Because I've never seen- I had never met a black woman PhD in math. And

> then I met about 20 or 30 of them… So just seeing that, and seeing that it can be done. That was enough for me. It was enough for me to be like, oh man, maybe I can do it. And then [I] met the lady who was the second African-American woman to get her PhD, ever. When I saw that, I was just like-you can do this, or whatever. And just learning all of the things that I learned from them made me feel like man I can do this.

We see that by being a part of scholarship programs, several participants were able to gain valuable internship experience and exposure to the broader mathematics community. These experiences proved valuable to their persistence in mathematics because they had access to mentors and gained valuable research experiences, allowing them to expand their understanding of various applications of mathematics and to connect with African-American mentors and role models in mathematics.

Peer Support in College

The most pronounced factor that impacted these students' success in college mathematics was peer support and encouragement, and this support took on several different dimensions. In their structured and loosely structured college programs, these students were advised of the importance of developing study groups and other peer support networks in order to "survive" in SEM-based disciplines. In the case of the students in the Sterling program, they were required to form study groups for their SEM courses. In many instances, this was the first time that these high achievers worked formally in peer support groups, and all of the participants found value in their peer support networks. Peer support took on a variety of forms from just students "being there" in the science and mathematics pipeline to an emotional support system, were their peers were "like family." Even in cases where the students were not required to or did not desire to work in academic study groups, they still found value in associating with "like-

minded" peers and engaging in a variety of peer support programs and activities that were a part of their scholarship programs and other social activities on campus.

One way that peers provided support is by simply "being there" and showing that the participants were not alone in being an African-American in mathematics. Several students expressed feelings of isolation at several periods during their academic careers. Being around others who experiences may have been similar provided an indirect support system. Even if there was no direct contact with these other high achieving African-American peers, several of the participants felt that just them "being there" was a source of motivation and support.

Joyce talked about the feelings of comfort and inspiration that she derived from hearing from her peers about a difficult class.

> … Just the fact that that they [other African-American students] did it, they are just like me keep me going. Like we [my peers and I] were talking about classes and they were talking, telling me about- 'cause I was in Calc 3 at the time- and so they were like "yeah I remember when I was in Calc 3"- and we could kind of share experiences and relate to being African Americans in technical fields, which you don't really have that many of… just like knowing people that have gone through this experience is encouraging because you feel like there is support, that there's other people who understand what I'm going through.

David shared about how being around students "just like him" was motivating and he has been searching to be around students like himself "all of his life."

> …to maintain [your scholarship], you must maintain a certain standard and it's very competitive. I'm in a group now where all these people- and this is what I've been searching for all my life- I'm in a group now, I'm surrounded by a bunch of people just like me. So, now I'm not the outcast so to speak. Or I'm not so different, where maybe something was wrong with me. Now I've found that niche where I'm surrounded by people who are just as competitive.

For David, being surrounding by other African-American students in his scholarship program made him feel less of an "outcast." Hence, his being around other students who

are “just as competitive” was a source of motivation. He was able to identify with these students in ways that he had not been able to do before being apart of this scholarship program.

The second level of peer support was participation in academic study groups, which were created specifically for a particular assignment or course. Sometimes students even created their schedules together in order to ensure an academic support structure for their mathematics classes. Anita, a mathematics major in the Sterling program, explains how being required to form study groups was initially an adjustment, but ultimately proved beneficial to her success in college mathematics.

> It [forming study groups] was very difficult, at first. Because its like- you’re so used to having to do everything by yourself, you don’t even know how to organize to work in a group, you know? And like it’s very different, ‘cause it’s like you’ve gotta do all these problems, and then like you’re comparing answers, and then like you have to either teach someone else or have someone else teach you things that you didn’t understand. And it’s just a different atmosphere…It’s much better than the way you were doing it before… instead of spending hours by myself trying to figure out something, I could just go ask someone else who understood it and be done in like 15-20 minutes. And that’s a big difference right there.

She elaborates in a second interview the nature of the support she receives in her peer support groups:

> ..I think like the people that I had, like the [Sterling] program that I’m in really helped me in the beginning, 'cause they like set up study groups for you, you already had people that you knew in your classes. And like it’s a minority program, so you know you got used to having that group of people sort of like as support for you. And like now that my classes most of those people aren’t math majors obviously. Now I see the difference in my classes where it’s only like 2-3 black people in my classes and everything like that, but it doesn’t bother me. You know what I mean?

Similar sentiments were echoed by other student in the Sterling program. Tina, while discussing her keys to successfully pursuing a mathematics degree, credits her peer study groups as a key component to her success.

> Definitely here at school, like the study- the support groups, and studying [are important to my success]. We've all- when it comes time to scheduling, what classes are you thinking about taking? Okay, this is the one I'm thinking about taking. And we try to be in the classes together. And that way we have a strong support group, and study- you know what I'm saying?

Michael agrees with Tina's sentiments. When asked what was essential to his maintaining a 3.7 GPA in mathematics, he responds:

> Study groups! Study groups definitely help…Definitely study groups helped me out a lot, because if there's something that I don't know, and they know it- they can help explain to me and vice versa. If I know something that they don't know, if I'm able to explain it to them, then to me it'll help- it'll show that I understand it even better because I can explain it to someone else… the material that they don't understand.

Karen's experiences are similar.

> … But the good thing about being it in college is that two of my really good friends here happen to be math majors as well. And we're all in the same scholarship program, and we take all our classes together, we study together, and it's almost like um I don't know- cause like my best friend here, her and I are both switched to math together, we've been together from the jump, and then our other guy friend he, we just stay together. And I guess because I have support actually in the [Sterling] program.

Non-Sterling scholarship students also attributed study groups as an important factor in their success in college mathematics. Again, while referring to her keys to success, Joyce reiterated the importance of study groups.

> Um, just finding people to study with [is important to my success]. Um, and just not getting bummed by one bad grade. Just kind of you know maintaining a positive attitude really helps. And again, just finding study partners and study groups.

She continues to elaborate on whether or not she would have been able to maintain her current GPA of 4.0 had it not been for her study groups. She explains:

> I don't think so. 'Cause I think it really, like that's how I learn sometimes. Is just like- sometimes I'll be presented with something, and it'll just be really off and weird, or I'll understand pieces and not the big picture. …Well actually, I prefer going to peers before going to instructors.

Shanice used peer support as well. When asked what composes her study regimen and whether or not she receives any academic support from her professors or peers, Shanice admits that she uses both the professor and her peers for academic support. In an earlier interview, she revealed that she worked with a study partner in some of her prior mathematics classes and she found working with this study useful and works with this friend in her current mathematics course

> I'm taking two math classes right now. And I have one friend in each of my classes that I do homework with. Um- and I go to office hours when I need to. Like, my teacher has office hours on Monday, Wednesday, and Friday. And I go if I have questions, whenever.

In addition to providing academic support, these peer support groups provided mental and emotional support as well. This emotional support ranged from just having other African-American high achievers to look to who understood their experiences to active emotional support in times of difficulty. While reflecting on their peer support group of fellow Sterling scholars and other mathematics majors, Tina and Karen speak candidly about how their peers provide more than academic support. Tina emphatically attributes her success as in her mathematics courses to her peer support groups. In fact, she creates her schedule with several of her peers in order to insure that they are in the same classes. She does this for academic as well as social support, and as the following except indicates, she views her peers as a vital lifeline.

> Definitely here at school, like the study- the support groups and studying [have made the greatest impact]… When it comes time to scheduling, we ask each other what classes you are thinking about taking. Okay, this is the one I'm thinking about taking. And we try to be in the classes together. And that way we have a strong support group, and study [group]… there for your mental and emotional support. So when we're studying, it's like "Okay, I'm tired. I'm getting tired of this." "No, come on, you can keep going." Or it's like "I don't understand this." "Well, I do. Let me explain it to you." You know, it's loving and supportive when we act together to support each other, type thing. ...I have friends who I'm together with, so we're like Oh okay, you know, it's one more semester- we can make it together. Or, you know-

Karen who is also a Sterling scholar shares similar sentiments:

> Well, right now it's definitely my friends who are in the major with me [that help me be successful] because we stick together very well. And I've been fortunate that there's just not like friends in math, but they're friends outside of math also. So they understand where I'm coming from when I'm like having a hard day... It makes it so much easier when you're in a course, and you're just like, Man I don't understand this. I mean, this teacher's this. Or, how do you get this? Because, I don't know, I don't think I could be successful without them. And we're each other's backbone.

Peer support networks were critical to these high achievers success as mathematics majors. The sense of academic and social support that these students gained from their peers made a tremendous difference in their success and persistence in college. Participants engaged in study groups that provided them with needed academic support. This was particularly beneficial to students in the Sterling Scholarship program who were required to participate in study groups. In addition to providing academic support, these peer support networks helped alleviate some of the isolation these students felt being high achieving students since they were surrounded by other like minded peers. These peer support systems also provided mental and emotional support, and in some cases served as an extended family.

Being connected to the African-American Community and Spirituality

As was evident in the high school data, participants expressed a connection with the African-American community and spirituality that was important to their success and persistence in school. This connection to other African American students and God continued in college and was evident by their connection to their African-American peers, reliance on their spirituality in times of difficulty, and belief that their ability to do mathematics was a gift from God.

Several students expressed that their ability to succeed in a challenging discipline such as mathematics was a result of being blessed with mathematical talents. Many of these students' explained their ability to grasp a difficult subject like mathematics as a gift from God. As Joyce's comments represents, faith in God was a source of much strength and perseverance. Since she saw her mathematics ability as a blessing, she felt a spiritual obligation to remain in mathematics. Joyce explains:

> Honestly, I feel like it's [my math ability] a gift to some degree. Like I feel like God blessed me with this talent to be good at math. And I feel like it's almost a duty of mine to persist in it and to advance that talent. So I think that's basically what's kept me in it. Like, not everybody can get through Differential Equations; everybody can't get through Linear Algebra. And so for me to get through it, and it not be that bad, I'm like obviously I have some type of talent for it. Either that or I just work a heck of a lot harder than everybody else does…. It's [my spiritual foundation] definitely a source of like strength and persistence, like I can do it. You know, definitely, I can do all the things through Christ who strengthens me, that type of stuff.

Other participants expressed similar sentiments. While discussing challenges that he faced in his introduction to proofs course, David explains how his spirituality was a source of strength and gave him the certainty that he would eventually overcome the challenges he faced in the course.

> …And so, I kept practicing, I kept practicing, I kept praying. You know, I'm a very religious person, and I lean on God for everything, and so I just kept praying. You know what? It clicked. I always knew- I knew it was going to click, I didn't know when. I went to office hours probably twice. And, I didn't really get what I needed from office hours. But I just kept praying and I kept doing homework, and I just kept looking at the book. And one day it clicked, you know? I always knew it was going to click, I just- you know.

He continues:

> Yeah, I can do it. Just, you know, if I pray enough and I study enough, I can do anything. That's the way I feel about it. And, I feel too that everyone has somewhat of a purpose, I feel like if you're doing what you're supposed to be doing, then things will happen for you. They may not happen when you want 'em to, but they will happen. And that's what happened with the 310 course. I didn't get it right away, but you know what sometimes? It's good for you not to get it right away. So it'll kind of teach you to be patient, and to just work at it, and keep working, rather than quit.

Michael expressed similar sentiments. While discussing what kept him in mathematics in college, Michael admits that prayer was a key component of his survival arsenal.

> Prayer [helped me persist] … Asking God to keep me alive, keep me sane, please. And [it] just eliminates stress for me, and also being part of organizations and having fun [eliminates stress]. So [God was] helping me to get through the hump.

Michael offered the following advice to other students who may be experiences challenges in their mathematics classes.

> Don't give up when you're frustrated. 'Cause there are times when I wanted to give up. Especially with dealing with certain professors, dealing with certain classes, I'm just like-if I drop it; I may stay an extra semester. Which I didn't really want to do, but- just don't give up, and- I don't know, to me it's a lot to do with faith, too. My religious background and my faith and stuff like that, that helps push me through**.**

The above data reveals that these high achievers had a strong connection to the larger African American community and spiritual foundation; both of these values were instilled in their parents at an early age. As they matured, these factors became increasingly important in their academic and personal success, particularly in college

when they were away from their families. Many of the participants credit this strong religious and spiritual foundation and community consciousness as a vital component to their success in mathematics and ability to "hang in there" when things became challenging in the discipline.

In college, they were all apart of structured or loosely-structured scholarship programs where they had access to faculty mentors, staff support, financial assistance, pre-professional activities, internships and most importantly peer support. All of these factors provided necessary support structures that they needed to continue their academic pursuits in mathematics. The next theme answers the fundamental questions: What made these students stay in mathematics? What was it about them as individuals that allowed them to follow though and use these structures to excel in mathematics in college?

Positive Attitudes about Mathematics

The most salient variable that participants noted as having the most profound impact on their decision to major in and persist in mathematics was that they liked mathematics. As mentioned earlier in the chapter, these high achievers cultivated an interest in mathematics throughout their academic careers. However, it was not until college that this interest manifested as a key motivational factor for their persistence in the discipline.

David, like many other students in this study, performed well in other disciplines in addition to mathematics. Hence, they had several options when it came to their academic pursuits. However, they choose to pursue mathematics because they found joy in studying, the discipline appealed to their talents and in some cases, they admit to

having a passion for the subject. Responding to a question surrounding why he choose to major in mathematics, David speaks openly about his passion for the subject.

> …Mainly [I choose mathematics] because that's what my passion was. I'm not a very philosophical person. I'm not a what-if person. I'm very concrete, meaning you know this is the way it is, this is the way it's going to be type thing. I'm not a what-if, I wonder if I can, I'm not very philosophical. I can do science, but that's not where my passion was. I don't know. With math, I've taken enough math classes to know that I enjoyed all of them, and I just love math. I actually love math. Like, I love it, nothing discourages me about it. Even when I fail, I just try harder the next time. And so, I feel like this is something I can do for the rest of my life.

Anita also attributes liking math as on of the main reasons she persists as a mathematics major, despite being one of a few minority females in many of her classes.

> I liked math. I don't see anything else that I would happy doing, so it was like I was going to go into mathematics….And now that my [college mathematics] classes, most of those people aren't math majors obviously. Now I see the difference in my classes where it's only like 2-3 black people in my classes and everything like that, but it doesn't bother me. You know what I mean? I just like doing mathematics.

Joyce understood that simply having mathematical talent was not sufficient for one to pursue mathematics in college. She compares her decision to persist in discipline to other students who had similar backgrounds as she did who choose not to major in mathematics or mathematics-related disciplines in high school. She credits her "liking math" as a key component in her being a "math person," a person who possesses mathematical talent and an enjoyment of the subject.

> I still think of myself as a math person. What is a math person? I think it just goes back to the fact that I actually like it [and] combined with the talent. I had some of my friends in high school who I thought were math people too, because we were all in BC Calc together. And they're off in school majoring in political science, and other things that have nothing to do with math.

When asked why she thought other students in her advanced mathematics classes did not choose mathematics-related majors, she responded: “They didn’t like it. Why they didn’t like it!”

In addition to enjoying mathematics, they also realized, particularly in college, that excelling in mathematics required hard work and perseverance. These high achievers were willing to engage in the discipline understanding that it would require them to work hard. Hence, they did not see anything inherently wrong with being required to work hard in order to understand mathematics. In fact, it was one of the things that attracted them to the subject. Several (6/8) participants credit their enjoyment of the challenges inherent in mathematical study as one of the reasons they choose to stay in the discipline. Anita, Joyce’s and David’s comments symbolize how liking the challenges of mathematics was an important personal factor that impacted their success and persistence in the discipline. Anita explains in vivid detail about how her enjoyment of the challenges of mathematics keeps her excited about mathematics. Unlike other disciplines that come relatively easy for her, pursuing mathematics provides a sense of accomplishment and internal reward through overcoming various challenges.

> It [math] is different from everything else that I have [studied]. In a lot of other classes I would just have to memorize information or just like spit it back out, or like you know things like that. But like math, I have to like actually think and try to do the problem. And I like the challenge that comes with it, and like, it’s not so hard that I can’t do it. I can actually like, after I sit there and looking at a problem for a while, I can do it [the mathematics problem] usually with work. And I like that. I like actually having to work for it… I just liked being able to look at a problem, and then figure out how can I go about solving this problem. Trying a couple of things, maybe they didn’t work, maybe they did. But then like when I actually finally got that answer, I got more satisfaction from that than anything else that I had tried academically. So that’s why, that’s what I liked most about math. Just having that satisfaction of having a problem, that seems kind of difficult at first, but I was able to solve it.

Karen felt similar to Anita about enjoying the challenges of the subject:

> I could have gone [in to other disciplines]. I really could have gone in a lot of directions. And some teachers told me that, especially my history teachers, and political science [teachers] also. I was a whiz in that stuff, but it wasn't a challenge to me. And that's the whole thing- and in the end, that's what goes along with math. Math is a challenge. And I think I would personally really like a challenge. I don't want everything in life to be easy. And I think if everything in life is easy, you lose your- you lose what life really is, what life is meant to be.

In Tennille's case, she considered changing her major from mathematics, with the intension to be a secondary mathematics teacher, to an elementary education major. Although she admits becoming frustrated with her mathematics classes and liking several of her education courses, she knew that if she left mathematics she would miss the challenge. In fact, even though education seemed like an "easier" option, she was convinced that taking the easy road was not necessarily a better option for her.

> ..In my freshman year I also started taking education courses. So I was a Math Ed student. And for a period of time there I didn't like the challenge. And I thought about just becoming an education major drop the math and just do the education. And my Aunt Agnes said "now, is that really what you signed up to do? I mean, you went in as a math major. And the education part sort of got added on. But is that really what you signed up to do? You should think about it before you just go and change your mind." I was going to become an Education major - an Education major here is easy.

I asked her why she chose to remain in mathematics, she responded by saying: "Because then you miss a challenge! Yeah, it's the challenge that keeps me going." The above data suggests that these high achievers enjoyed mathematics, particularly because it was challenging.

Belief in the Importance of Mathematics: Mathematics Opens Doors

Not only did these high achievers enjoy mathematics and the challenges that it brought, they also believed that mathematics was important and perceived studying mathematics as a worthwhile endeavor. Although none of the participants initially

declared majors in mathematics, they believed that mathematics was important, even though they were not clear what specifically one could do with a mathematics degree. And since all of them initially declared majors in other SEM related disciplines, they understood that mathematics was important in their academic endeavors. Once they were mathematics majors, they saw even more value in its pursuit. They perceived mathematics as a way to keep their options open and they could pursue anything they wanted with a strong background in mathematics. When asked why she majored in mathematics and what she saw herself doing with her mathematics degree, Anita exclaims:

> "Exactly what can I do with math?" "Anything you want!" "Okay, exactly what?" "Just anything- just pick something and then you can do it with math." I'm just like, I guess I'll do math.

Shanice also believed that studying mathematics is a way to keep her options open and she could go into a variety of career fields by obtaining a degree in mathematics:

> Yeah. I mean, it's a lot more open-ended than like computer science or engineering. Like I don't have to be a mathematician or something, you know? Like I can- like I don't know what the things are, but I think that you can do a lot of things with a math major. I think it's a lot more open-ended than like a more specified major.

Tina also believed in the importance of a mathematics degree. She understood that others would "need her" services in any career field. She explains her beliefs about the importance of mathematics:

> A lot of the other fields like engineering, use math. They might not go into the abstract algebra, but they still gotta know some integrals, some derivatives, and some applications of it. And like I said, I don't know if it's one of those things just like society, where [you won't use math]. I do feel like a lot of people do struggle with math, though.

Speaking about the various opportunities that are available to mathematics majors, Karen makes the following observations:

> … You can be an applied major and do modeling, and model all different types of problems and, like, in my modeling class we're working on biology problems, traffic problems, chemical kinetics problems, but we don't necessarily know all the background of what actually is going on with the chemical kinetic problem, but you have some idea. And you can think logically enough to where you can set up the problem so that chemical engineers can solve it, or you could solve it yourself. So I just think that math bridges the gap between all majors basically, because you can go into mathematical biology, you can go into mathematical education, and you can go into, you know, computational mathematics.

Similar sentiments resonated in both David's beliefs also:

> A lot of people say: "what do I need math for?" What do I need this high school diploma for? And they just kind of give up and they say the way it is, and that's the way it's going to be forever. And, to just- tell them to stay encouraged, that things will work out if you just keep doing right. Just keep doing the right thing, and one day you know doors will open that nobody can really close.

The above data suggest that in addition to having positive attitudes about mathematics, they believed in the importance of studying mathematics. Mathematics was seen as a "kind of scientific liberal arts degree" which kept their options open to careers in the sciences and having a degree in mathematics would provide them a wealth of future opportunities. Michael summarized this idea in our last interview:

…there were so many opportunities with mathematics, that you're not stuck with just doing one thing. Like with biochemistry, I was stuck, actually doing more of a life science approach. But with math, you can do life science, engineering, computer science. Anything academically uses math. But everything needs math.

Opposing Forces: Issues of Race, Gender, the Mathematics Culture and Academic Ability and their role in providing "challenges" to their successful persistence in mathematics in college

Despite having access to family, educational and personal support structures, their academic journeys where not without difficulties. These students perceived several

factors that provided challenges to their successful pursuit of mathematics. Although these students perceived several overt and covert obstacles as they moved through the mathematics pipeline, they did not see these challenges as insurmountable nor did they view them as a justification for leaving the discipline. In fact, in times of challenge, they report using a combination of support structures and internal and external motivators to get over these "opposing forces" of success. The remainder of this chapter will focus on the major challenges that these students perceived in their pursuit of mathematics through college and the ways in which they navigated these pitfalls in order to persist in mathematics.

Obstacles of Race and Gender

African-American and Female: Double Jeopardy

Many of the African-American females site a variety of perceived obstacles in their mathematics experiences that related specifically to their race and gender. Mathematics was sometimes perceived as a disciple dominated by white males; hence being African-American and female was sometimes viewed as double jeopardy. First, they had very few African-American female role models because they were no African-American female mathematics faculty members in any of the universities. Given the absence of African-American female mathematics faculty, some of the female participants relied on White female faculty members for support and encouragement. Secondly, they were faced with negative perceptions from white male professors and peers. Anita explains how not seeing other African-American women in mathematics makes it a little harder for her see herself as a mathematician.

> You always want to see yourself in an area. You know what I mean? So it's like, it's easier if you can see other black women doing it, than it is if you see all white

> men doing it. 'Cause then you're like, well, already I stand out. Because I don't-obviously I don't look like them. I don't obviously fit into this group. Maybe there's something else that maybe I should be doing. You know what I mean?

Not seeing other African-American females "doing" mathematics created feelings of isolation and caused Anita to question her own ability to "fit into" the larger mathematics community. Although these feelings were not pronounced enough to have her leave the disciple, not having other African-American role models was a source of concern for Anita and several other female participants.

Karen expressed similar sentiments when discussing the importance of having positive role models as an African American female mathematics major.

> Having a role model, and knowing somebody else was out there and done it, is important. Because I think that's what's so hard, some of the time, is going [around] thinking you're the first, and you're the only one to do it [be successful in math]. That's what gets you discouraged. But there's already people who have done it for us, so that all we need to do is to look for them and see what they've done, and know what we can make it through it. A lot of people think it's impossible to get a PhD in math anyway, but then when you add the factor of being a woman and the factor of being black, it seems that much harder.

Not only did these African-American female students lack role models, in some instances, peers perceived it "strange" that an African-American female would pursue a technical discipline such as mathematics.

> I've actually had one of my friends [told me that] it's strange that you're a math major. And I was like, well how so? And he was like, well first of all, you're a girl. He's a computer engineer. Like he's obviously noticed that in a lot of his classes, there are only like two or three girls out of 30 people. And he's like, that's very strange that you're a girl, and plus like you're black as well. You know?

Being a brother in mathematics

It was not just the African-American females who expressed race and gender related challenges, the African-American males in the study also experienced their own

set of barriers as they moved through the mathematics pipeline. In a candid discussion about the few numbers of African-American males in his mathematics classes and even fewer numbers of African-American male mathematics majors, David reflects on his experiences as a brother in the discipline and the isolation he felt. He also describes not having African-American male role models and how it impacted him and possibly other African- American males.

> **…**I can't name one other math major that is a male. I can't. Like, honestly, I can't. And that's not a good thing. You know, I'm not saying that like Oh I'm proud of myself. It's discouraging to me because it's- you know, I feel like I'm holding the weight of the world on my shoulders…This [weight] runs very deep. I think a lot of it is, just don't have, a lot of men growing up just don't have role models. You don't have role models that excel. You just kind of have men around you that are just doing the bare minimum. So I think a lot of guys growing up, they kind of grew up thinking; well I'm just going to do enough to get by.

In addition to feeling like he has the "weight of the world on his shoulders" because of his experiences as an African-American male in mathematics, he has been challenged by negative perceptions from white peers. David shared an incident in his calculus III class where he felt isolated. He perceived that the other students in the class viewed him as less capable because he was an African-American male.

> It's pressure that a lot of people are looking at you, waiting on you to you know, fail, to say that they knew you couldn't do it. … I always feel like the students in my classes are looking at me, like waiting on me to drop the class before the Drop period. Oh, he isn't going to be here. I took Calc 3 one summer, and um, it was like- it was only 20 people in the class. ..No one ever came to me before the first exam. …No one ever came to me and said, Hey what'd you get for problem 21? You know. I got the first exam back, I made- the average was like a 60-something, and I made a 90. I made a 90. …I didn't say anything. I didn't let anyone else know. But their instructor, he was like, yeah, but you're the only one to get one of the problems right. And the next exam I made like a 95. And so, I think after the next exam, that's when students started kind of looking toward me, like Hey what'd you get for problem 8? But I made an A in the class… I feel like there's a weight on me that's not on most students.

He believed that the source of the weight on his shoulders and the other students' unwillingness to talk to him was because he was an African-American male, who dressed in "hip-hop" clothes. Because he was a African-American male who did not fit the academy's vision of a "scholar," he believed that he was viewed as "less capable" than the other, mostly White students. This perception, he believed, was the source of his feelings of isolation; however, once he had "proven himself" by performing well in the course, his fellow students seemed to value his input. However, he felt that other students did not have to prove themselves in order to be accepted, which he refers to as a "weight on his shoulders."

Students' Negative Perceptions of Faculty

Although several participants report having had positive interactions with faculty and receiving support and encouragement from faculty, the data also suggest that some of the participants' experiences with faculty were not positive. Michael speaks candidly about his unfavorable perceptions of mathematics faculty and his assessment of their inadequate teaching skills:

> I believe that you have to have certain qualities to be an instructor. And a lot of them [mathematics faculty] just don't have that. They just don't know how to teach. Like they're good researchers, don't get me wrong. But they just can't teach. There's that teaching aspect that's missing.

Tina shares similar experiences with a faculty member she encountered:

> .... There was a teacher last semester who was like that [very negative], and everyone- I'm talking black, white, Chinese, everybody just hated him, because his perception was kind of like, if you don't get it, you're dumb. Like he would say things like this is obvious. In our teacher evaluation, I was like, you can't use words like "This is obvious", "Clearly". 'Cause it might not be obvious or clear for someone. And then you'll say, does anyone have a question? Who wants to raise their hand when you just said "This is obvious"?? So, I just think it's like the people skills.

In addition to citing poor teaching by mathematics professors as a barrier to success, Michael notes that the increased focus on theoretical mathematics was another obstacle that he faced, particularly since his talents and interests lie in applied mathematics

> … Well, I just don't like the math department here. I don't even like the math program, the undergraduate math program here because it's mostly pure mathematics, pure mathematically based, and I don't like pure mathematics. I want to go toward the applied mathematic route. And the professors here I don't think are really good professors, in my opinion.

Other participants expressed similar sentiments, and often referred to mathematics faculty as "not people persons," "unfriendly," and "disconnected," which they admit sometimes made it more difficult to solicit their support. However, despite these perceptions of some faculty, participants were able to get the necessary support and resources they needed to be successful in their courses. Oftentimes, they relied on the more amiable and helpful faculty members and their peers for support.

Self Perception of Themselves as Mathematics Learners: Not One of the Geniuses

Although it was evident from the data the students liked mathematics, believed in their ability to do it, and were able to rally support and overcome academic challenges, many participants did not see themselves as one of the smartest students or what they referred to as "one of the mathematics geniuses." Several participants believed that they had mathematics talent; however, this talent was not enough to have them get mathematics "quickly" and "without help." Particularly, when students found their theory courses challenging, they would explain their struggles by acknowledging that they were

not the "special" super-bright mathematics students that they believed would "get it" quicker than they had. Therefore, they saw themselves as less capable than those they perceived were "mathematics geniuses." This idea is demonstrated by Joyce. In our second interview, I asked her to explain why she did not see herself as a "mathematical genius," she responded:

> I think there's definitely the perception that like the most prestigious part of math is the theoretical part. I don't want to necessarily say that those people [the geniuses] are better, or smarter, but I think there is kind of that stigma. That's part of the reason why I would say that I'm not one of the genius people. 'Cause I don't like the theory. [It] doesn't appeal to me, and I don't get it as readily as other people do. So, that's probably where that comes from.

She continues:

> I think the geniuses are the people who take what exists and understands it very quickly, and they're the ones who derive all the new things. So I don't think I'd be the one to be like the Einstein, deriving all the crazy new formulas and whatnot. Um- but I can definitely understand the ones that are already out there, so.

Joyce's experience reveals that she not only saw that only mathematical geniuses would understand or enjoy theoretical mathematics, she believes that these "geniuses" would be able to understand this type of mathematics quickly and be able to "derive new thing." Although she did not reveal who these students were or whether or not she had experience with such students, she firmly believed that such students existed and that she was not one of them, even though she had a 4.0 GPA in her mathematics coursework.

Shanice had similar beliefs about what it meant to be a genius. "If I was a genius, then maybe I'd get a 4.0…. I feel like a genius is able to understand everything. So if I don't understand something, then I'm not a genius," Shanice argues. Tina's comments mirror Shanice's beliefs.

> I'm not the genius. I'm like, I'm not the genius, and I'm not the one who's like, look at it, Oh I get it. I work hard. Like, I have to work hard to make sure I understand. I'm the one who put in the hours to study. I'm the one that do the recommended problems, plus the homework problems. You know, I'm working at it, especially those theory classes.

We see how the high achievers in this study saw their mathematics ability in relation to others that they believed was more capable than they were. These "geniuses" were apart of an elite group of mathematics students for which they were not a part. These "more elite" students were in fact the ones that were going to "derive new things" or "get mathematics quickly," which implies that they were not the ones that could do this. What was most common in all of the participants' stories was that, although there was little evidence to suggest that many of these geniuses existed, the participants had clear notions that these highly capable mathematics students existed. Since they had to work hard to understand theoretical mathematics, they perceived themselves as not a member of this most elite group of budding mathematicians, despite their excellent performance in their mathematics courses.

Chapter Summary

This chapter provided the results of my data collection and the major themes developed from this data. In the next chapter, I will use these themes to develop overarching themes that reflect the family, educational, communal, and personal factors that had an impact on these high-achieving mathematics majors' success and persistence in mathematics. I will indicate, where appropriate, where these overarching themes reflect, contradict or refine what exists in the literature. In addition, I will provide a discussion of how this study's findings can be used to inform k-12 and university practice and policy and directions for future research.

The themes that will be discussed in chapter six include (a) the role of social and cultural capital in these students' success in mathematics (b) the role elite academic programs in developing students' human capital (c) the role of college scholarship programs on students academic and social integration at the university, and (d) social consciousness and spirituality as a framework underlying these high achieving students' success.

CHAPTER 5

DISCUSSION AND CONCLUSION

The purpose of this study was to identify and understand the factors that influence high-achieving African American mathematics majors to persist and succeed in mathematics. Borrowing elements from social, cultural, and personal factors identified in mathematics education research and factors from the college persistence literature relating to African-American students, this study sought to understand which factors shaped the participants decision to persist and succeed in mathematics. This study employed interpretive case study methodology in which interview data from a purposeful sample of eight high achieving African-American mathematics majors was collected. Interview data was transcribed verbatim and analyzed using a start list of codes and open and axial coding. I also utilized QSR NVivo software to assist in coding and compiling of data into thematic categories. Each student was considered a case and data was reported by cross-case analysis. Qualitative methods were used in order to capture the essence of the groups' experiences and to give voice to these students who have been successful in mathematics. All of the participants in this study were American born African-American students who were sole products of the American school system (Brown, 2000; Goodwin, 2002; Ogbu 1991). The participants were junior or senior mathematics majors with grade point averages of 3.0 or higher.

The major research question guiding this study is: What perceived factors contribute to high-achieving African-American junior and senior mathematics majors' decision to persist and succeed in mathematics through college? This study also sought answers to the following sub questions:

1. In what ways do these high-achieving students perceive the role of the family, educational institutions, the community in their success and persistence in mathematics?
2. How do these high achieving students perceive their own role in their success and persistence in mathematics?

The data obtained from individual interviews were analyzed to generate themes that provide an understanding of the family, educational, communal and personal factors that had an impact on these high achieving African-American students' success and persistence in mathematics.

The remainder of this chapter briefly reviews the findings of the study. Next, there is a discussion of findings organized around five themes that address social cultural capital, elite academic programs in K-12 institutions, structured scholarship programs in college, development of personal agency, and the role of social consciousness and spirituality. The chapter ends with implications for practice and policy and areas for future research.

Summary of Findings

The study's findings, which are detailed in chapter four, are summarized here by the research questions guiding this study.

1. How do high achieving African-American mathematics majors perceive the role of their family in their success and persistence in mathematics?

The findings reveal that the family, specifically the parents played a major role in the participants' success and persistence in mathematics through college. The mothers provided essential pre-school experiences and supervision that created a nurturing

environment and helped foster an initial interest in learning. This early interest provided an academic structure that was essential to these students' latter success in school. Their fathers, many of them were employed in science related fields, helped cultivate an early interest in science and mathematics.

Once these students entered formal schooling, their parents continued to play a significant role by instilling success-related values and a spiritual and social consciousness, providing academic and social support and encouragement, and advocating for them in school. Values such as giving back to the community, valuing education, hard work and pursuing their interest were fostered in their children from an early age. Parental advocacy in elementary school was instrumental in their success in school. Parental advocacy as defined in this study is parents taking intrusive actions to navigate their child's educational paths to ensure their success in school.

2. How do high achieving African-American mathematics majors perceive the role of k-12 educational institutions in their success and persistence in mathematics?

Elementary and secondary educational institutions also played an important role in these students' success and persistence in mathematics. Because these students were placed in accelerated, honors, or gifted and talent programs by the end of third grade, they had access to caring teachers and quality mathematics learning experiences generally not awarded to African-American students. In these accelerated programs, teachers motivated them and exposed them to challenging mathematics coursework. They also participated in activities and competitions that cultivated their interest in the subject. Many of them talked about liking math, or being good at it, which motivated them to stay in mathematics.

The participants did not discuss their middle school experiences because they did not perceive any critical experiences that impacted their success in mathematics. One explanation could be that they were already tracked in accelerated programs since elementary school. Essentially middle school was a continuation of these same academic experiences and what was important was their ability to stay on track during these years.

Once these students finished middle school, their mathematics coursework made them eligible for honors, Gifted and Talented (GT), Advanced Placement (AP), and science and technology programs in high school. In these programs, they were required to take advanced level mathematics courses which were challenging. Because these elite programs had a structured academic track, these students perceived these higher level courses as mandatory in order to remain in these programs. In these accelerated programs, were there were few African-Americans, peers played a significant role in their success and persistence in mathematics. The findings indicate that the participants believed that they had "no choice" but to take advanced mathematics courses and participate in mathematics related activities. Also being apart of these programs gave them the necessary mathematics coursework they needed to major in science and mathematics related disciplines in college.

3. How do high achieving African-American mathematics majors perceive the role of higher educational institutions in their success and persistence in mathematics?

All of the participants were a part of a structured or loosely-structured scholarship program in college. These programs gave them access to one or more of the following support services: financial support, peer and faculty mentoring opportunities, study groups/peer support, summer bridge programs, program staff support, internships

opportunities, attending professional programs and conferences, and student-based mentoring programs. Access to these support structures, particularly faculty and peer support, was instrumental to their retention in mathematics. Of particular importance was their access to faculty members who gave them valuable information that influenced their decision to become mathematics majors.

As they pursued these degrees, the participants experienced several academic challenges, particularly during their first theoretical mathematics class[1]. Participants relied on faculty and peer support to overcome these challenges. Peer support networks, mainly those consisting of other African-American students in their scholarship programs, were critical to their academic success and provided essential motivation and encouragement. In fact, many participants cited that peer support and encouragement was a critical factor in their persistence as mathematics majors. Peer support was perceived as particularly important to student in the Sterling Scholarship program, a science-focused merit-based scholarship offered by a PWC attended by four of participants. In addition, being apart of these scholarship programs, particularly the Sterling Scholarship Program, allowed them to participate in internships and professional conferences, which allowed them to connect with the larger mathematics community and interact with mentors and role models that also motivated them to persist in mathematics.

4. How do high achieving African-American mathematics majors perceive the role of the community in their success and persistence in mathematics?

The role of the community was most pronounced in the participants' college years. In their pre-education and early educational experiences, parents served as the

[1] These were courses where students had to construct deductive mathematical proofs as opposed to performing mathematical operations using formulas or algorithms.

dominant force that navigated the students' pathways toward success. In high school, they became aware of themselves as members of a larger African-American community and hence developed a social consciousness, which scholars also refer to as racial identity (Ford, Havin & Schuerger, 1993) that motivated them to persist. This awareness originated from their parents' values and their religious participation. In college, however, they were not under their parent's monitoring nor did they have the family support and a church community. As a result, their sense of spiritual and social consciousness served a more dominant role in their success and persistence in college when the mathematics coursework became much more challenging. In high school, they became aware of themselves as members of the larger African-American community and hence developed a social consciousness that motivated them to persist. In college, being away from their primary families, encountering challenges in their academic coursework, and becoming aware of the gender and racial disparities in mathematics seemed to awaken their connection to others (e.g. peers, the African-American community, and God). Hence, they relied more heavily on these community influences in college more than at any other stage of their academic careers.

5. How do these high achieving students perceive their own role in their success and persistence in mathematics?

During their pre-educational and elementary educational experiences, participants indicated that they had a small role in their success and persistence in mathematics. They noted that their parents imparted a variety of values and held high expectations of them and they merely complied with these high expectations. In the participants' world, they had "no choice" but to succeed in school because that was what they were required to do

because their home environments promoted academic achievement. Once they entered elementary school, the teachers in their accelerated programs also held high expectations and provided them with challenging and engaging mathematical experiences that helped to cultivate an interest in mathematics. This interest grew as they progressed through school, and once they entered high school, the participants continued in accelerated academic programs that required them to take advanced mathematics coursework. They obliged this expectation and took advanced mathematics coursework that gave them necessary mathematical content knowledge that they needed for science and mathematics-based majors in college.

It was not until college that the students' personal agency became apparent. After declaring majors in other science-related fields, the majority of the participants became dissatisfied with their initial majors. They changed their major to mathematics because they saw a math as a way to keep their career options open, enjoyed the subject and believed in their ability to succeed. Many participants experienced challenges in their mathematics coursework; however, given their high academic self efficacy, determination and perseverance, they were equipped to overcome these challenges.

Social and Cultural Capital: Key to Success in the K-12 Mathematics Pipeline

The participants in this study had access to various forms of capital (educational, social and human resources), which were invested and mobilized to increase the likelihood of positive educational outcomes (Bourdieu, 1986, Coleman, 1988; Lin, 2001; Putnam, 1993). Although there are various conceptualizations of social and cultural capital (Bourdieu,1986, Coleman, 1988; Lin, 2001), researchers contend that social and

cultural capital, just as economic capital, can be invested and mobilized by a group or individual to yield positive outcomes in society such as wealth, power or reputation (Lin, 2001). According to Bourdieu (1986), cultural capital refers to the system of attributes, dispositions, language skills, cultural beliefs, values and knowledge derived in part by ones parents that define and individual or groups class status. These cultural values, knowledge and beliefs are held by the dominant culture and are legitimized as the "objective" culture and values of the society. Hence those who have values, beliefs and dispositions of the dominant cultural group have "capital" that they may use to profit from social and cultural institutions such as educational systems.

Highly connected to cultural capital is social capital. Social capital is "sum of resources, actual or virtual, that accrue to an individual of a group by virtue of possessing a durable network of institutionalized relationships, mutual acquaintances and recognition (Bourdieu & Wacquant, 1992, p.119). In Coleman's (1988) conceptualization, which is most commonly used in educational research, social capital is essential in communicating the norms, trust, authority, and social controls that an individual must understand in order to succeed. As evident in this study, students possessed several forms of social and cultural capital that they accumulated and mobilized that were critical to their success and persistence in mathematics. The social and cultural capital these students possessed clearly distinguished them as middle class. Their family economic status was a significant factor in their having access to various forms of social and cultural capital. These students come from two-parent homes where one or both parents were college graduates and provided them with valuable academic resources. In addition these parents departed success related values and dispositions comparable to those held by the

educational institutions and navigated and advocated for their children's education. These students also participated in elite academic programs where valuable social networks were cultivated. What follows is an exploration of each of these.

The Social Capital of the Two Parent Home

All of the participants began their lives in a two parent household where their mothers and fathers played distinct and complementary roles in the participants' pre-educational development. The data suggests that these high achievers began their lives with caring, supportive and engaged parents who provided them with early educational experiences and an early mathematical experiences that would shape their readiness for and achievement in school. These parents, particularly the mothers, had at least an undergraduate degree or where pursuing their degrees while raising their children. Several of the participants' mothers were educators and understood how to navigate the educational system on behalf of their children. This study's findings are consistent with other researchers that suggest mother's education has a positive effect on African-American children's educational achievement, attitudes about learning, and mathematics achievement (Hrabowski, Maton, & Greif, 1998; 2002; Ma, 1999; Moody 1998; 2000; Walker, E. 2006; Walker, 2006; Sanders, 1998; Schreiber, 2002). What this study adds to the research is an understanding of the nature of these mothers' interactions with their children that produce these positive educational outcomes. In particular, mothers provided these high achievers with early academic learning experiences that prepared them for school, gave them ongoing verbal encouragement to succeed in school and in mathematics, advocated for their children's educational placement and provided the academic support early in their elementary years. Hrabowski, Maton, & Greif (1998)

found that parents of the high achieving African American males in his study also committed themselves to preparing their sons for kindergarten, provided them with early learning experiences in mathematics and science, and advocated for their children in school. These findings are consistent with the findings of the above study. The resources that these parents provided were a form of social capital for which the students in this study were able to benefit (Coleman, 1988).

Another finding of this study is the role of the fathers in the participants' success in mathematics. Fathers played a crucial role in fostering an interest in mathematics by providing mathematics related experiences. In addition, these fathers in concert with mothers help instill values that allowed their children to succeed in mathematics. Although other researchers suggest that parents influence African-American student achievement (Hrabowski, Maton, & Greif, 1998; 2002; Ma, 1999; Moody 1998; 2000; Walker, E. 2006; Walker, 2006), the specific role that each parent plays in cultivating mathematic achievement is not clear. Also, there needs to be more investigation of the specific role that fathers play in the achievement of African-American students. Two parent households allowed each parent to actively participate in their children in and out of school lives. Many researchers have argued that being from a two parent home has positive effects on African-American students' achievement (Coleman, 1988; Kennedy, 1997) and this study's findings supports this research.

This study confirms findings from other studies (Hrabowski, Maton, & Greif, 1998; 2002; Ma, 1999; Moody 1998; 2000; Sanders, 1998; Walker, 2006) that highlight the importance of parents in the educational success of their children and reveals some of the ways that students benefit from this two-parent home structure. This does not imply

that single parent households are not able to cultivate academic success. However, since all of the participants in this study began their lives in a two parent household, the findings of this study suggest that having both parents has a positive impact on students' success in school. In addition, given that in most cases, both parents were also educated gave the participants a level of social and cultural capital that many of their African-American peers did not possess.

Instilling Congruent Values and Dispositions

Participants commented on the ways that parents instill values such as hard work, discipline, social responsibility, excelling academically and spirituality. Students relied heavily on these values, especially when they experienced academic difficulties in college. The values that were instilled in them by their parents were congruent with those honored by the school; hence these students demonstrated character traits and academic abilities that were rewarded by the educational system. We know from the literature that Parents instill values in their children that are useful to them in school (Hrabowski, Maton, & Greif, 1998; 2002), support their success in mathematics (Martin, 2000) and foster positive attitudes about learning and education (Hrabowski, Maton, & Greif, 1998; 2002).

This study supports these findings and illustrates how these values shaped their success and persistence in mathematics. What we learn from this current study is the importance of parents imparting values that promote academic learning and social development. These values are important when studying a disciple such as mathematics because math requires hard work, perseverance and abstract thinking skills established early in life.

One of the most interesting finding of this study was the meaningful ways that parents advocated for their children. The findings of this study reveal that these cultural and socially affluent parents, particularly the mothers, understood the educational system and navigated it for their children. They provided them with the academic and social resources that they needed to be successful in school. This form of social capital is vital to students' success in educational institutions (Hrabowski, Maton, & Greif, 1998).

Elite Academic Programs: Solidifying Forms of Capital through Quality Mathematics Education

The students in this study began schools with high levels social and cultural capital. Once they were "granted" access to accelerated programs in elementary school, it paved the way for their subsequent success in mathematics. For the majority of these students, this access to accelerated programs occurred in the third grade, which suggests that third grade is a critical grade in a students mathematics education. It has been noted that African-American male students who enter schools with great promise undergo negative transformations in schools that manifest itself in the fourth grade (Kunjufu, 1985). Researchers refer to this as the fourth grade failure syndrome, which some scholars use to explain the poor performance of African-American students, especially African-American boys in schools beginning in fourth grade (Kunjufu, 1985).

From this study we learn that critical placement decisions are being made in the third grade that can help explain why some African-American students experience failure in the fourth grade. Since the participants were placed in advanced programs early in their careers, they had access to advanced mathematics curriculum. Other researchers on high achieving mathematics students cite similar experiences (Hrabowski, 1998; Moody,

2004). However, African-American students of average ability are not as fortunate to have access to this advanced curriculum, hence, this can have a negative impact on their subsequent achievement.

It is unclear from this study the mathematics skills and concepts that they learned before third grade that were essential to their advanced placement. Understanding the nature of these high-ability students' mathematics experiences before third grade may be useful in preparing other African-American students for accelerated mathematics coursework, a preparation that was vital to their subsequent academic placement in advanced mathematics programs throughout their academic careers.

Once in these programs, students had access to caring teachers who held high expectations and exposed challenging mathematics curriculum. This finding is consistent with findings from other scholars that suggest the importance of caring teachers who communicate high expectations (Martin, 2000; Ladson-Billings, 1995; Moody, 1998; 2000; 2004; Tate, 1995). In elementary school, it was the nature of the mathematics experiences that shaped these students' success and prepared them for advanced mathematics study. Some of the key components of these mathematics classrooms suggest that the teachers were creative and able to connect the mathematics to the students' lives in meaningful ways, which has been noted as contributing to African-American students' success in mathematics (Ladson-Billings, 1994; 1995; Tate 1995).

The finding of this study also reveals the importance of structured high school programs that demand students to take advanced mathematics coursework, which is important to them acquiring the knowledge they need to pursue mathematics intensive

majors in college (Oakes, 1990). It is not clear from the data that if these students would have taken these courses if they had not been enrolled in these programs.

Structured College Scholarship Programs and Peer Support Provide the Link to Academic and Social Integration

The college success and retention literature stresses the value of having students socially and academically integrated in the college experience (Tinto, 1992; Pascarella & Terenzini, 1991). Social and academic integration allows students to feel apart of the college community, overcome academic challenges and take advantage of the various resources available at the university, which increases their overall performance in college (Tinto, 1992). Although Tinto's work does not address African-American students, many scholars use concepts from Tinto's framework as a way to understand the experiences of African American college students (Allen, 1992; Astin, 1982, 1992; Fleming, 1988; Fries-Britt, 1998) and particularly African-American high achievers in college (Fries-Britt, 1998; Fries-Britt & Turner, 2002). Tinto (1997), while discussing reasons for student's departure from college, argues:

> Voluntary departure appears to be the result more of what goes on after entry into the institution that of what may have occurred beforehand. Though it is obvious that that pre-entry experiences, for instance as measured by intentions and commitments, do affect subsequent departure, research supports the notion argued here that the character of one's integrative experiences after entry is central to the process of voluntary withdrawal (or persistence on the other side of the coin). Of particular importance are those experiences which arise from daily (academic and social) interactions between students and faculty inside and outside the classroom. Other things being equal, the more frequent and rewarding those interactions are seen to be by the student, the more likely the student is to persist-indeed the more likely he or she is to develop socially and intellectually (p, 82.)

The above quote speaks to the nature of the college experiences reported by the African-American high achieving mathematics majors in this study. Being in these

programs, allowed these students to integrate both socially and academically in the university and most importantly in the on-campus and broader mathematics community. Their entry into the field of mathematics was shaped by faculty members that they met in these programs. Had it not been for these faculty members, they may not have even considered mathematics as a viable major.

In addition, their peer groups were often fostered through their participation in their scholarship programs. These peers were particularly helpful once they took their first theory-based mathematics course, which served as a sort of "initiation" into the mathematics community. These courses required students generate abstract deductive arguments, for which none of students reported having prior experience. Consequently, the participants relied on their mathematics community to help support them through these academic challenges. As result, they developed strong peer support structures that not only supported them academically both socially as well. These results are consistence with other studies on African-American high achievers (Fries-Britt, 1998; Fries-Britt & Turner, 2002). Having access to like minded peers also lessened their feelings of isolation and helped to cultivate a commitment to the mathematics, which scholars argue is important in retention (Fries-Britt, 1998, 2002; Fries-Britt & Turner, 2002; Grandy, 1998; Tinto, 1997).

Since these high achievers were a part of various scholarship programs, they had access to a variety of resources that were instrumental to their success in college. They all received some level of financial support. Hence, none of the participants spoke of financial challenges that some researchers site as reason for student's departure from college (McJamerson & Larke, 1989). More importantly, being apart of these scholarship

programs gave them access to faculty that encouraged, supported and advised. In addition, some participants reported being connected to the larger mathematics community through internships and attending professional conferences. Participating in these internships and conferences provided another layer of support because they had access to mentors and role models (Hill & Pettus, 1990), and explored various applications of mathematics in the career world.

In this study, the majority of the participants, seven out of eight, attended predominately white universities, which limited the researchers ability to adequately compare the experiences of high achieving mathematics majors at PWU's versus HBCU's. There is evidence to suggests, however, that the student attending the HBCU reported more positive faculty student interactions than those students attending the PWU's. However, the students in the Sterling scholarship program, reported a similar positive experience with faculty as a result of participating in the scholarship program, suggesting that PWU can create minority supportive academic environments by developing minority focused programs. These programs, however, should focus on building faculty-student support opportunities, hold high academic expectations for African-American students regardless of their prior academic performance, and encourage and cultivate peer support communities that nurture students' academic and social integration into the university community. These initiatives would go a long way in improving PWU's retention of minority students in mathematics and allowing these students to excel academically.

The findings from this research are also consistence with Treisman's (1992; 1985) work that suggests African-American students benefit from peer study groups in

mathematics. Although Triesman's study focused on students in calculus, the findings from this study suggest similar benefits of peer study groups in theoretical mathematics courses. The participant's descriptions of what occurred in their study groups reflect some of the components advocated by Treisman (1985) including collaborative problem solving of challenging mathematics problems and having the support of more advanced students. Also, it seemed that students benefited from these groups because working in study groups allowed the students to communicate abstract mathematical ideas with peers who helped them clarify, extend and refine their mathematical thinking. This had a positive impact on their deductive reasoning skills and ultimately their ability to write and defend their mathematical proofs. In addition, students were able to clarify mathematical terms and theorems, teach other students, and co-construct mathematical proofs, which helped them increase their performance on their homework and exams.

Students saw themselves in partnership with each other, and students relied on each other to help clarify mathematical ideas. This collaboration seemed to benefit these mathematics majors in particular because of the abstract nature of the discipline. Unlike other mathematics and science related disciplines such as engineering, computer science, biology and chemistry, much of mathematical inquiry is based on abstract theorizing that is not generally rooted in experimentation and/or concrete applications. Hence, students need to develop their ability to reason abstractly and justify mathematical claims using rigorous deductive reasoning. The data from this study suggests that students working in peer study groups were particularly useful in their mathematics classes because it allowed them to make sense of abstract mathematical

concepts in a non-threatening environment, develop their mathematical reasoning skills, and relieve their anxieties about constructing proofs.

The Role of Social Consciousness and Spirituality in Their Success and Persistence in Mathematics

When first designing this study, I did not conceptualize the role of the community in the way that the students in this study did. I believed that community influences would consist of students' exposure to mathematics through community activities, role models and other mathematics- related experiences. However, the community's role in these students' success and persistence in mathematics was more than I initially conceptualized. The "community" was seen by these participants as the larger African-American community, their spiritual and/or church communities, and their personal relationships with God. These community forces were driving forces in their persistence in mathematics, particularly when they experienced academic challenges in college. And surprisingly there was little evidence to suggest that the nature of these community experiences were mathematically specific, however, these community influences had a positive impact on these students' mathematical success.

In their pre-education and early educational experiences, their parents served as the dominant force that navigated their pathways toward success. In high school, they became aware of themselves as members of a larger African-American community and hence developed a social consciousness that motivated them to persist. This awareness came primarily from their parents' values and participation in church activities. In college, however, they were not under their parent's monitoring nor did they have as

much family support. As a result, their sense of spiritual and social consciousness served a more dominant role in their success and persistence in college when the mathematics coursework became much more challenging. In high school, they did well in the subject with little effort and their teachers served as a primary source of support. However, in college mathematics became increasing more challenging and had to rely more heavily on their peer community and their spirituality for support, encouragement and motivation.

The community's role in their persistence and success in mathematics was revealed primarily in three ways. First, these students created family like peer communities that served as sources of academic, social and moral support. Secondly, these high achievers saw themselves as a part of a larger African-American community and had a level of social consciousness that motivated them to persist in mathematics. This social consciousness took on many forms including: a desire to give back to the community, seeing their success as a representation of the success of other African-Americans, and having the opportunity to shatter stereotypes about African-American in mathematics. Lastly, these students considered themselves as spiritual and saw their mathematics talents as a "divine" gift. They also felt that persisting in mathematics was "God-ordained," since they were blessed with mathematical talents and skills, good parents, and other privileges that they should not squander. The remainder of this section will discuss how social consciousness and spirituality impacted these high achievers success in mathematics in college.

Social responsibility for giving back to the community

One of the ways the community served as a driving force for several of these high achievers in by giving them a greater reason to achieve and be successful. They saw themselves a part of the larger community of African Americans and identified with their peers. This identification gave them another reason to defy society's expectations and "succeed" in a discipline that was not particularly welcoming to African-Americans and other minorities and those with limited mathematics backgrounds. This social consciousness was reflected in their engagement academic and social peer support networks that was key to their persistence in mathematics in college. The African-American community provided motivation for some of these high achievers to succeed, which was demonstrated in two ways. First, they felt a social obligation to do well in order to serve as a role model for other African-Americans. Secondly, they saw their persistence as a statement to non African-Americans that African-Americans were capable of succeeding and persisting in technical disciplines.

Seeing their success as reflective of the community contradicts some earlier finding about African-American high achievers who are often perceived as desiring to assimilate into the dominate culture by "acting white" (Fordham 1988; Fordham, S. & Ogbu, J. 1986; Ogbu, 1991) . For the students in this study, their racial and cultural identities were motivators in their persistence in a white-male dominated discipline. They did not wish "to separate themselves" from the community, they wanted to use their mathematical ability to serve the community. Achieving in mathematics was more than a personal goal that yielded individual rewards, these high achievers saw that the entire

African-American community would benefit from their success and persistence in mathematics.

Overcoming negative stereotypes

Another aspect to these students' social responsibility was their desire to shatter negative stereotypes concerning African-Americans in mathematics. Because they saw themselves as representative of their race, many of the participants saw their persistence in mathematics indication that African-American were capable of excelling in mathematics. They were aware of the limited numbers of African-Americans in their upper-level mathematics courses, the negative perceptions that African-Americans had about mathematics, and the racially biased attitudes that some teachers and faculty displayed. Their decision to persist in was somewhat shaped by their desire to disprove some of these negative stereotypes.

Their desire was to "prove others wrong," by remaining in mathematics (Davis, et.al., 2004; Phillips, 2005). Moore, Madison-Colmore, and Smith 2003 found similar experiences in the African-American male engineering students they studied and referred to this phenomena as the "prove them wrong syndrome." In the Moore, Madison-Colmore, and Smith study, many of the participants alluded to the notion of the stereotype threat and how they worked harder to disprove the stereotypes. Because of these perceived stereotypes, the African-American males in the above study became even more determined and committed to engineering when they perceived that their intellectual capability in engineering was doubted or slighted. The study's findings suggest that African-American mathematics majors are motivated to remain in mathematics for the similar reasons.

The importance of spirituality

As mentioned earlier in this discussion, spirituality was an important factor in these students' success and persistence in mathematics. Spirituality is defined as the degree to which individuals endorse a relationship with God or a transcendent force that brings meaning and purpose to their existence and affects the ways in which one operates in the world (Armstrong, 1996). Some scholars have investigated the impact of spirituality on the academic performance of African-Americans college students (Ross, 1998; Walker & Dixon, 2002). Some of this scholarship, spirituality provides another layer of motivation for African-American students to succeed (Kirst, 1993, Ross, 1998; Walker & Dixon, 2002).

Using quantitative methods, Walker & Dixon (2002) found a positive correlation between spirituality and academic achievement. What this research adds to this existing body of work is how spirituality serves as motivation factor for students' persistence in mathematics for which little research explores. In particular, the findings of this research suggests that instilling a since of spirituality in African-American children and providing them with religious activities helps cultivate a connection with others and a sense of spiritual strength that they can rely on, particularly during challenging times. For those African-American students who choose majors in white male dominated disciplines such as mathematics and have little exposure to African-American role models, spirituality and social consciousness can provide a sense of groundedness and purpose that may assist in their persistence in these disciplines.

From Compliance to Personal Agency: the Evolution of the Student's Role in His or Her Success in Mathematics

In this study, students used the resources available to them such as parental, educational and peer support to increase their knowledge and abilities in mathematics. This acquisition of mathematical knowledge and skills was made available through the various parental and school-based networks. Specifically, the students adopted various knowledge, beliefs, values and dispositions that increased their ability to succeed in educational institutions and particularly in mathematics. Coleman (1998) contends that this integration of knowledge, skills and dispositions congruent with those held by the dominant culture has a positive impact on individuals in social systems such as education (for a review, see Dinka & Singh, 2002).

The participant's role in their own success in mathematics evolved from simply complying with the expectations and values instilled in them to developing their own self-efficacy, an individual's general belief that he or she can accomplish a task (Bandura, 1986; Wigfield and Eccles, 2000; Mau, 2003) and personal agency, which refers to one's capacity to originate and direct actions for a given purpose (Zimmerman & Cleary, 2006). Self-efficacy has been found to have a positive impact on a students' personal agency (Zimmerman & Cleary, 2006). As seen from the finding section, these students had parents who were instrumental in their educational lives and had a tremendous impact on their success in school mathematics. Initially, the students merely complied with their parents' values and expectations. However, in college that came to a "fork in the road" and after some searching decided to change their majors to

mathematics. This was an act of emancipation in some sense because they were no longer willing to continue in a major that they did not enjoy. Majoring in mathematics allowed them to reclaim "themselves" and fully acknowledge and embrace their "love for the discipline." This finding is similar to what Martin (2000) found in his study of successful African-American students he studied. He comments:

> Although I refer to a range of dispositional factors and strategies that contributed to their success as important, an important and often neglected component was individual agency. This agency emerged in the contexts of both the community forces and the school forces that students lived with on a daily basis. A particular important finding was the degree to which successful students recognized and responded productively to their surroundings. They did this by engaging in a kind of self definition by opposition and resistance to what they considered negative influences (p. 28).

Other scholars agree with Martin that an individual's personal agency has been said to affect academic achievement (Bandura, 1986; Pajeres, 1996; Zimmerman, 1990). However, much of this research does not address how personal agency affects African-American students, specifically those who achieve in mathematics. Hence this research fills a void in the literature and helps us understand how individual agency is cultivated and exercised in African-American students in mathematics. The findings of this study also reveal that participants exercised this agency only after complying with authority figures (parents and teachers), who encouraged them and held high expectations of them. The students' personal agency was exercised after they had accumulated ample self-efficacy and love for mathematics that was necessary for them to take ownership of their own success in the discipline.

Positive Attitudes and High Sense of Self Efficacy in Mathematics

Another major finding from this study was the positive attitudes that these students had for mathematics. Scholars agree that positive attitudes about mathematics

impacts students' achievement and persistence (Zeldin & Pajares, 2000: Pajares, 1997), and this is particularly true of African-American students (Stickel & Bonnett, 1993; King, 1995). While some researchers suggest that African-American students are turned off by the challenges they face in mathematics (Clark, 1990; Oakes, 1990; Seymour & Hewitt, 1997) or become helpless as they work to understand difficult mathematics material (Powell, 1990), these high achievers enjoyed working through challenging mathematics in their courses. Even as the mathematics became more theoretical, which several students did not enjoy, they enjoyed working through these problems and ultimately reaching an understanding of the material. The findings of this research suggests that engaging African-American students in challenging mathematics problems and providing them the support they need to overcome these challenges, may help them develop more positive attitudes about the subject and ultimately decide to persist in the discipline.

Closely connected to students' positive attitudes about mathematics was students' self-efficacy in mathematics. "Self-efficacy beliefs influence the choices people make and the courses of action they pursue. Most people engage in tasks in which they feel competent and confident and avoid those in which they do not (Pajeres, 1997)." Particularly, researchers have found that the mathematics self-efficacy of college undergraduates is more predictive of their mathematics interest and choice of math-related courses and majors than either their prior math achievement or math outcome expectations (King, 1995; Pajares, 1995), and the findings of this research support these results.

Simply liking mathematics and working hard were not the only elements in their success and persistence in the discipline. They had a fundamental belief in their ability to

succeed in mathematics despite the challenges they faced, and this belief was instrumental in their choice to persist in mathematics. In fact, as the challenge of mathematics intensified in college, they relied on their own self-efficacy to overcome these challenges. As they mastered increasingly challenging mathematical material, their self efficacy increased.

For example, participants expressed initial frustration with "doing proofs" and had to make serious academic adjustments to do well in their more theoretical mathematics courses. They overcame these challenges by relying on their peers, faculty and God, and as a result, they became more confident and competent in their mathematics ability. Through having these mastery experiences, students' self-efficacy in mathematics increased and their motivation to persist in mathematics strengthened. These experiences represent what researchers refer to as mastery experiences, which researchers argue are the most influential source of self-efficacy beliefs (Bandura, 1986; Pajeres, 1997;).

High self-efficacy in mathematics is strongly correlated with students, particularly African-American students' mathematics achievement (King, 1995; Schreiber, 2002) and persistence (King, 1995), and the results of this study support these findings. It appears that providing these high achieving students with challenging mathematical experiences and having these students mobilize their resources to overcome these challenges had a positive impact on their success and persistence in the discipline. As summarized by Pajares (2002):

> Self-efficacy beliefs also help determine how much *effort* people will expend on an activity, how long they will *persevere* when confronting obstacles, and how *resilient* they will be in the face of adverse situations. The higher the sense of efficacy, the greater the effort, persistence, and resilience. People with a strong sense of personal competence approach difficult tasks as challenges to be mastered rather than as threats to be avoided. They have greater intrinsic interest

> and deep engrossment in activities, set themselves challenging goals and maintain strong commitment to them, and heighten and sustain their efforts in the face of failure. Moreover, they more quickly recover their sense of efficacy after failures or setbacks, and attribute failure to insufficient effort or deficient knowledge and skills that are acquirable.

The above quote characterizes to the experiences of the African-American high achievers who participated in this study.

Although the participants in this study demonstrated a high level of self efficacy; many of them did not see themselves as "one of the geniuses," or "very smart." This implied that their academic self-concept in mathematics was not as high. Since these students were surrounded by other high achievers and had to rely on outside resources to understand the more challenging mathematics, they did not seem to see themselves as one of the brightest students. In their minds, one could only be a "geniuses" if he or she could "get math instantly" without help. In spite of this belief, many saw themselves as mathematically talented and believed they did have a gift to understand mathematics eventually, although they were unlike the "geniuses" who they believed understood theoretical mathematics easily.

The above findings suggest that even though these African-American high achievers found receiving support from peers and faculty valuable, they saw this need for assistance as an indication of a mathematical deficiency. This idea seemed to contradict their beliefs that they were blessed with mathematics ability and had a high self-efficacy. Other scholars cite a similar disconnect when studying the self perception of gifted students who are placed in homogenous classes with other high ability students (Marsh, 1987).

The mathematics culture seems to promote individual achievement over collaborative effort, which appears to contradict the African-American cultural philosophy embraced by mathematics majors in this study. Scholars note that African-American students seem to value collaborative work and thrive in environments where they are allowed to interact with their peers (Fries-Britt, 1998; Fries-Britt & Turner, 2001). However, the students' perceived that in mathematics, individual accomplishment was valued over group effort and because of this perception and they did not see themselves as a mathematical "genius." This contradiction may help explain the disconnect between the participants' academic self concept and academic achievement (i.e. grades they received). This finding suggest that the mathematics community needs to do a better job of promoting the value and importance of collaborative effort, which may help African-American students feel more adept to pursue advanced mathematics coursework and excel in the discipline.

Implications for Practice

This study has a number of implications for practice. First, educators can use the results of this study to inform parents about the importance of supporting, encouraging and advocating for their children. Educators and parents must build partnerships in order to insure the success of all children and instill values that will allow their children to succeed in school. In some cases, educators may have to initiate and cultivate these partnerships; however, the returns in student achievement may prove worth the initial effort. Also, holding high expectations for all students, providing meaningful and challenging mathematics experiences, and caring for students academically and socially helped set a solid mathematical foundation for which the success of these students were

built. Hence, educators must adopt practices that address both the academic and social needs of their students and provide them with enriching mathematics experiences. Educators can incorporate culturally relevant mathematics experiences that foster a love and appreciation of mathematics and develop African-American students' confidence in their mathematics abilities.

Secondary mathematics educators must encourage all students to take advanced mathematics courses regardless if these courses are necessary to meet graduation requirements. The findings of this study suggest that African-American students respond to the suggestions of caring educators who believe in their mathematics abilities. Consequently, they will continue to take advanced mathematics courses well beyond the number of courses they need to graduate, thus allowing them to be exposed to necessary mathematics knowledge they will need to declare majors in mathematics in college. College mathematics faculty must become aware of the challenges students face in their transition from applied, procedure driven mathematics course to theoretical mathematics courses. Considerable effort must be made to make this transition effective and structures that support students must be embedded in the instructional framework of these courses. In addition, preliminary courses should be designed that orientates students to the type of thinking required in their upper level mathematics courses and help them transition to writing formal mathematical proofs. These courses should also encourage and create structures for peer study groups and use cooperative learning groups as an integral part of their in-class instruction.

Mathematics education researchers must continue to examine the experiences of African-American high achievers as well as high achievers from other ethnic groups in

order to understand the types of mathematical experiences that have positively impacted their success in mathematics. The findings from this study provide insight into the experiences of students who excel in mathematics and from their experiences we can enhance our understanding of best practices.

Even more compelling the findings of this research suggest that students, even those who come from supportive families and educational institutions, need ongoing support structures in k-12 and post-secondary institutions. These academic and social support systems were essential to these African-American students' success at every phase of their journey through the mathematics pipeline. For this reason, we should seek to provide all students with structured support at every level if we wish to increase the numbers of minority students in mathematics.

Implications for Policy

Third Grade Placement and Tracking

Policy makers must play close attention to third grade and the critical educational decisions that are made in this grade, particularly how African-American students are tracked. Although it seemed as if tracking served the students in this study, there is also evidence to suggest that most African-American students are not as fortunate as these participants. Students who are placed in lower track classrooms are not engaged in the types of mathematical learning experiences encountered by the students in this study. And from the participants' accounts, there seems to still be a racial divide between students in higher and lower tracked classrooms and the instruction in "lower tracked" classrooms are not comparable to those in the mostly White upper tracked classrooms.

Although there is much debate over the merits of homogenous (tracked) versus heterogeneous (inclusion) mathematics classrooms for high achieving students (Finlayson-Reed, 2004), the findings of this study suggest some benefits for high achieving students placed in tracked classrooms. The researcher does not advocate for either of the above philosophies, however all students no matter what mathematics classroom they attend must be provided high quality mathematical experiences from caring and supportive teachers who hold high expectations for all students. There are challenges to doing this, but this must remain the goal of mathematics educators and policy makers at every phase of students' educational lives.

College Program Policy

Although it was clear that these students being is scholarship programs gave them access to resources that allowed them to both socially and academically integrate into the university, similar initiatives can be developed for students who are not apart of college scholarship programs. In particular, university policy makers, stakeholders, and university mathematics educators must emphasize the importance of peer support groups in the academic success of students. Also, universities can provide opportunities for freshman and sophomore students to connect with faculty in order to promote valuable academic communities. Developing these relationships between faculty and students should be a priority for university policy makers and should not be advocated only for the academically talented students nor should they be postponed until students reach their junior and senior years.

As the findings of this study suggest, relationships between faculty and peers provide the necessary catalyst for students to strengthen their commitment to the

discipline, alleviate feeling of isolation and increase their academic performance. Hence, university policy makers responsible for the retention of all African-American students must create programs and policies that encourage these relationships such as: providing faculty incentives for mentoring freshman and sophomore students, allocating resources for summer and semester programs that promote peer learning as vital to students' success in mathematics and related disciplines, and providing incentives for students to participate in these faculty and student support programs. These policies can go a long way to creating the necessary environment promote success in mathematics and other mathematics-based disciplines.

Areas for Future Research

Even though this study contributes to the scant literature on African-American high achievers, particularly in mathematics, more studies are needed to develop a better understanding of the experiences of high-achieving African American students. The results of this study can be used as a framework to investigate this population. Given some of the factors identified in this study, large-scale longitudinal studies should be conducted using a larger sample of participants. These studies will allow mathematics educators to understand if similar factors are pervasive in a larger population of African-American high achieving mathematics majors.

In addition, a comparative study can be conducted on other minorities and White students with similar academic and social profiles as the students in this study in order to compare and contrast factors that promote persistence for different ethnic groups.
In addition, comparative studies can be conducted on African-American students with similar academic and social profiles who choose to leave mathematics. In these studies,

researchers can examine what factors were missing from students who fail to persist and the nature of their family, educational, communal and personal experiences that lead them to pursue other disciplines or drop out of college altogether. A comparative study of high achievers, average achievers and low achievers with similar profiles could be compared in order to further explore the similarities and differences in their pre-educational, elementary, secondary, and post-secondary experiences that may explain the various levels of achievement as college mathematics majors.

Another question that could be addressed in future research is: what happens in third grade mathematics classroom that determines student placement and what key mathematical concepts are developed in this grade that was "instrumental" in this placement. A further investigation of this critical year in students' mathematics trajectory should be examined more critically in order to uncover how to prepare African-American students to have access to positive and challenging mathematics experiences.

Since this study was designed to investigate a number of factors that impacted high achieving African-American mathematics majors' success and persistence in mathematics, there were limitations on the researchers ability understand deeply each individual factor. Future research should investigate each of these factors thoroughly. Not only must future research seek to understand these factors more deeply, there must be an exploration of the quality of these experiences in various populations of African-American students.

Researchers in higher education can investigate in more detail the nature of student study groups in mathematics, the discourse of these groups and what specific aspects of these groups are the most influential on African-American students' success in

college mathematics. In particular, comparative studies need to be conducted on the nature of student interactions in mathematics study groups in programs such as the Sterling Scholarship Program opposed to study groups of students not participating in such programs. This research can provide us with qualitative differences and similarities in these study groups and what elements of these study groups makes the most difference in students' college mathematics achievement and retention.

Future studies can be done that compares the experiences of African-American high achieving mathematics majors experiences at both PWU's and HBCU's, specifically their experiences in peer study groups. It is unclear from this research the similarity and differences between the peer support groups of African-American students at HBCUs and PWUs. Conducting research that compares the experiences of students in both types of institutions can provided additional insight into how African-American students support and encourage each other in both environments. In addition, this research can help officials at each type of university create peer support programs that are appropriate for the specific needs of students at their institutions.

Researcher Reflections

As mentioned earlier in this study, I brought several biases and values that impacted the nature of this study. As an African-American female who was a high achiever in mathematics, I had a unique lens through which I collected, analyzed and reported the findings of this study. In this section, I will reflect on the similarities and differences between my experiences and the experiences of the participants, discuss my reactions to some of the major findings of this study and provide some probable explanations for the differences found in participants' experiences versus my own.

Unlike the participants in this study, neither of my parents had a college degree nor did I grow up in a middle-class household. My parents worked unskilled and/or service related jobs and rarely had the time to visit the school or take an active role in my education. However, I did have two parents who held educational expectations and required that I do well in school. Although they did not actively engage in preparing me for school or at least I do not recall this engagement, my parents valued education, made sure that I went to school everyday, insisted that I bring home "good grades," and demanded that I not give the teachers any "problems." These values were instilled in me at an early age; however, my parents gave little attention to what I was learning in school but rather were concerned about my academic performance and behavior. As a result, I made good grades in elementary school but did not take any accelerated classes and was placed in low-level junior high school classes, which meant you took basic junior high school mathematics.

Unlike the participants in this study, I was not tracked in third grade nor was I placed on an accelerated academic track early in my educational career. After being placed in a low-level seventh grade section, my homeroom teacher realized that I was "wrongly placed" and recommended that I be considered for the gifted and talented section in the eighth grade. I am still uncertain about what he saw in me that had him make this recommendation; however, his suggestion saved me from the academic abyss. I was placed in the second highest mathematics class in eighth grade, and there I began to flourish. Instead of taking middle school mathematics, I took Algebra from the best mathematics teacher I had ever had, who thought that I had something special or at least that was my experience. I remember learning how to expand binomials using Pascal's

triangle and being asked to expand $(a + b)^{21}$. This was extremely exciting to me because I was doing "really hard" mathematics and Ms. Mitchell new I could do it. When she asked a difficult question to the class, I could hear her stern voice call out "Ellington," probing me to give the answer, and more often than not I was correct. In her class my love for mathematics was born and had it not been for my seventh grade teacher's recommendation and the experiences I had in Ms. Mitchell's class, I doubt if I would be in the mathematics pipeline today.

My above recollections point to what other participants shared about the importance of caring teachers who held high expectations. Although my positive mathematics experiences came later in my academic career, they were very influential in my success in mathematics. Ms. Mitchell was tough on me and did not allow me to give her substandard work. I learned to appreciate and value mathematical thinking. Because of my own experiences, I was surprised to learn from my participants that third grade was a critical year in their academic lives and middle school was not as influential. Given that I went to school in the late seventies and early eighties, there may be time related differences in making school placement decisions. What was important though was that I was eventually tracked in the accelerated mathematics classes and this helped shaped my subsequent mathematics experiences in high school.

After graduating middle school having taken two years of Algebra, I entered high school with enough mathematics credits to take Geometry in the tenth grade and Algebra II in the Eleventh grade. The high school I attended did not have an "elite" structured program; however, I did take classes with the "smart" kids. I recall having good mathematics teachers who held high expectation; however, my own love for mathematics

made me eager to take all of the mathematics the school offered. I made up my mind that I was going to take Calculus in the 12th grade even though the school did not offer it. So in the summer of my eleventh grade year, I enrolled myself in a paid summer program that allowed me to take Trigonometry which at the time was the prerequisite to taking Calculus. When I returned to school in the fall, a seasoned mathematics teacher agreed to teach me calculus during his planning period. Although I did not cover much calculus, I learned enough to prepare me for the first two weeks of college calculus.

Like the other high achievers in this study, my love for mathematics and my confidence in my mathematics abilities were important factors that impacted my success in the discipline. I was not, however, pushed to take higher level mathematics coursework because of a structured program. For me knowing that I could do mathematics and enjoying the idea of taking challenging mathematics coursework, made me continue to take higher level mathematics courses. I was also clear that I may not have been the "smartest" in mathematics because I was not exposed to the most rigourous mathematics course that students in the better school had been exposed. However, I knew that with some support I could understand it, and truthfully I knew I was talented.

Another similarity in my experience and the experiences of the participants was that I also began college in a major other than mathematics. I changed my major to mathematics because I loved it, thought it was cool to have such a "hard major" and felt that being a mathematician would keep my future options open. I had no idea what I could do with a mathematics degree, but I was clear I would be marketable.

In addition, I went to college on an academic scholarship. As a scholarship student, I had very few financial concerns despite not receiving much financial support from my

parents. As a requirement for my scholarship, I had to maintain a certain grade point average and although we were not officially identified as a cohort, I lived in a dormitory with other honor students. Most of my friends and study partners were also honor students and were not mathematics majors. Living with these like minded peers had a positive impact on my success, and once I declared a major in mathematics, I meet other mathematics majors with whom I studied with and relied on for support in my mathematics classes.

As I reflect on my own journey I see many parallel experiences as the high achieves I studied and some differences. However, what stands out in all of our experiences is the fact that loved doing math, we were exposed to caring teachers and we participated in structured scholarship programs. In these scholarship programs, we built critical peer support networks that were essential to our success as mathematics majors. And although my parents were not middle class they still held high expectations of me and expected me to do well in school, which set the foundation for my subsequent success in the discipline.

Conclusion

This study has presented some of the family, educational, communal and personal factors that impact African-American students' success and persistence in mathematics. Although additional research is still needed on this population, the findings of this study supports existing research on African-American high achievers and provides a glimpse into the experience of successful mathematics majors. This study's findings and the above discussion suggest that the family, particularly the parents, educational institutions, and the community worked in concert to ensure that these high achieving African-

American mathematics majors had the access to and opportunities for success in mathematics. At each phase of their pre-academic and academic lives, they had structures inside and outside of school that gave them the support they needed to be successful and persist in a demanding discipline such as mathematics. These family, educational and community support structures also gave them a sense of outside accountability to parents, teachers, peers and God. Because of this accountability, these high achievers perceived that they had no choice but to achieve and persist despite any challenges that they may have faced. In addition, they had several forms of adult advocacy that helped them navigate their educational careers. Over time, however, they developed their own self-efficacy and personal agency that allowed them to take ownership of their own mathematics success in college.

Appendix A
Informed Consent Form
For Participating Students

Project: High-Achieving African American Mathematics Majors: A Case study of Socio-cultural and Personal Factors that Influenced Their Persistence and Success in Mathematics

Purpose: The purpose of this study is to understand the factors that influence high-achieving African American mathematics majors to persist and succeed in mathematics. This study will examine the students' personal, social and cultural experiences and their perceived impact on their success.

Procedures: To achieve the purpose of this study, I am being asked to participate in a maximum of four-minute interviews over a six-month period. These interviews will be conducted at my convenience at a location of my choice and these will take approximately 60 minutes each. I will also be asked to review interview transcripts and the researcher's interpretation of my experiences in order to insure an accuracy and validity. This will take approximately 20 minutes before each interview. I may also be asked to participate in a focus group interview with other participants in the study. This will take approximately 45 minutes

The kinds of questions I will be asked may include: Why did you choose a major in mathematics? Explain some experiences that lead you to pursue mathematics? How did your community impact your achievement in mathematics?

Confidentiality: I understand that my name and location will remain anonymous throughout the study. Any publications of documents that are a result of this study will contain pseudonyms that will disguise my identity. At the conclusion of the study, all manuscripts and data will be stored in a locked file cabinet in a secure location on the campus of University of Maryland. All data from the study will be destroyed after 10 years.

Risk: Because I will be asked to donate time to this study, a possible risk may be some loss of academic study time. Also, I will be asked questions that delve into my personal background, home, school and educational experiences, which may cause some anxiety. I understand that all data collected in this study will remain confidential, and all serious efforts will be undertaken to protect my identity.

Benefits: By agreeing to participate in this study, I will be helping to advance knowledge of what impacts African-American students success and persistence in mathematics. In addition, I will have access to the researcher, who is a college mathematics instructor. She may provide me with academic and/or moral support, if needed. I am free to ask questions or withdraw from participation at any time and without penalty.

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I have read all of the above material concerning this research and I,

_____

(name printed)

_____ agree to participate in this study.

_____ do not agree to participate in this study.

Signature _____

Date _____

Appendix B Initial Interview Protocol

Research Question:	**Interview Questions**
General Background	1. Can you tell me a little about yourself? 2. What is your educational and family background? 3. How do you like college? Being a mathematics major?
What perceived factors contribute to high-achieving African-American junior and senior mathematics majors' decision to succeed in mathematics through college?	4. What would you say was the key(s) to your success in mathematics?
What perceived factors contribute to high-achieving African-American junior and senior mathematics majors' decision to persist in mathematics through college?	5. Why did you choose to major in mathematics? 6. Explain some of the experiences that lead to your decision to pursue mathematics in college?
In what ways do they perceive the role of educational institutions in their persistence and success?	7. Was there anything in your school experience that influenced you to achieve in mathematics? 8. What experiences in school (K-college) would you say most shaped your success in mathematics?
In what ways do they perceive the role of the community in their persistence and success in mathematics	9. How did your community impact your achievement in mathematics? 10. Were there any community programs, persons or activities that influenced your decision to continue in mathematics?
In what ways do they perceive the role of their families in their persistence and success in mathematics	11. How would you describe your family experiences? 12. What role did your family play in your success in mathematics?
In what ways do they perceive their own role in their persistence and success in mathematics?	13. What kind of mathematics student are you? 14. Is there anything about your personality that you would say makes you a successful mathematics student?

Appendix C Sample Questions from Second Interview for Anita James

1. Was your liking mathematics the only thing that kept you motivated to succeed? If not what else do you think motivated you to succeed?
2. You spoke a lot in our first interview about peer support, can you elaborate on the nature of this support and how peers helped you persist as a mathematics major?
3. Can you talk more about the types of support you received from the Sterling Scholarship program?
4. You said that your parents encouraged you to try your best in school. Can you describe what you meant by this and what was it that your parents did?
5. In our first interview, you discussed how several faculty members went "out of their way" to support you," what does this mean to you? What are some examples of the types of actions that constituted going out of their way?
6. You mentioned that you still enjoyed mathematics even when it became hard. Explain.
7. What kind of community support did you receive that shaped your success in mathematics?
8. When you took your first proof course you said that you had to adjust to a new way of thinking. What was that like for you? How were you able to make the transition from the old to the new way of thinking?
9. Can you share about your father's role in your success?
10. Other students, you say, are scared of math and you are not. Why? What is the difference for you?

Appendix D Sample Questions from Second Interview for Tennille Smith

1. You spoke a lot in our first interview about the opportunities available in math. Do you think that the opportunities available in math impacted your decision to stay?
2. You discussed that being "pushed" by your professors, teachers and aunt gave you no choice but to succeed in mathematics. Can you elaborate?
3. Was being tracked in GT classes influential in your success in mathematics in elementary and high school? What about these classes made the difference?
4. On page 21 of our initial interview you talked about being smart. What do you mean by smartness?
5. You talked about folks standing behind you. What does this look like?
6. Did you have any peer support throughout your academic career and did this support impact your success at all?
7. Can you talk more about you upbringing before you moved in with your aunt. Were both of you parents present in the home and what were some of your experiences?
8. You talked about not wanting to let "people" down. What people? Why not?
9. You talk about Dr. Simon's Prove class and how it set the foundation for your higher level mathematics courses. Can you tell me more about this class?
10. You talked about how it was important that you kept your scholarship. Say more about this?

Appendix E Sample Questions from Second Interview for Tina Jones

1. You mentioned throughout our first interview that you mother's being an educator impacted your educational decisions, can you explain this? What did she do to impact your decisions?
2. You said that you did not know the opportunities available in mathematics. Is this the reason you did not select mathematics as you initial major? How did you become aware of the options in mathematics?
3. You mentioned that you took honors classes in high school. Can you talk about these classes? How did you get selected for these programs?
4. It seemed like the students in the Sterling program were like extended family. Can you discuss how they serve as family?
5. You keys to success are parents, internships, peer support and spirituality. Am I correct? What about these things made the difference?
6. In our first interview, you refer to mathematics thinking as boot camp. Can you tell me what you mean by this statement?
7. You talk about how you are "not one of the smart ones," yet you see that you have the ability to do mathematics when you work at it. Can you tell me what you mean by smart?
8. In you application classes you admit that that you just need to practice to do well where as in your theory you have to do more work. Can you discuss this further?
9. Have you experienced failure in mathematics and if so how did you overcome this failure?
10. You said that you trust your study group and that there is no completion between you and your peers. Why not? What makes you feel so comfortable in these groups?

Appendix F Sample Questions from Second Interview for Joyce Michaels

1. If you had not been in the honors classes in school, do you think you would have been able to go as far in mathematics as you have? Why/ why not?
2. You talked about how your dad used to play with the computer with you when you were young. Can you discuss how this affected you in mathematics?
3. Would you say that it was your mother, father or school experiences that had the greatest impact on your interest in mathematics? How?
4. You talked about your experiences in 3rd grade with Ms. Brown several times in our initial interview. What was special about your experiences with her?
5. Like several other participants, you changed your major to mathematics. What made you change your major? Why did you not come to school as a mathematics major?
6. You said that your Advanced Calculus teacher was very nice. Can you talk more about your experiences with the faculty?
7. What is it that keeps you being successful and interested in mathematics given all of the challenges you discussed?
8. You said that your mathematics talent is a gift from God. Can you say more about what you mean by this? Do you feel that everyone has this gift?
9. What type of support did you get from your church and how did this support impact your success?
10. Can you think of any experiences that could have made you even more successful in mathematics?

Appendix G Sample Questions from Second Interview for David Simmons

1. "I enjoyed doing homework in math and it was fun." Why was it fun? What about mathematics did you enjoy? Was there anyone who initiated your interest in the subject?
2. You relied heavily on yourself and your faith in God to get you through the rough times in your academic career. Correct? How did God help? What do you think contributed most to the mathematics clicking for you?
3. When you talked about your mom, you said that she had complete confidence in you. Can you share more about this?
4. You said that you did not work much in study groups but you do have friends from your scholarship program that you say are like you in many ways. Do these friends have an impact on your persistence as a mathematics major?
5. In your program, you serve as mentor to other mathematic majors. How has this impacted your journey in mathematics? You talked about these students going through some of the same struggles that you did. Can you tell me more about these struggles?
6. You gave an extensive account of you life before and after your parents' divorce. You discuss how your mom's being there for you in your early years as an important factor in whom you are today. What did you mom do to shape your success?
7. You said that you have mathematics talent from God. What do you mean by this? Why do you attribute your success to God?
8. Talk more about the high school teacher that signed you up for advanced mathematics classes. Why did she do this? Why did you listen to her?
9. Did you always know that you would do mathematics for the rest of you life? How and when did you come to know this?
10. Do you see yourself as successful in mathematics? Why? Why not?

Appendix H Sample Questions from Second Interview for Karen Johnson

1. You discussed throughout our first interview that there were faculty that supported you and those who were out to get you. Can you discuss what you mean by this?
2. You explained how much of the support you received were from women. Can you discuss this and highlight some specific things that these teachers did that were supportive?
3. You got a lot of support from your parents. Can you describe what this support looked like?
4. How important would you say your high school experiences were in your persistence in mathematics? What specifically about these experiences were impactful?
5. You attributed your success to God giving you the parents that you have and being blessed with mathematics talent. You admit that these were advantages that other students did not have. Can you elaborate on this?
6. How did grades or your pursuit of grades influence your success in mathematics?
7. You said that your parents taught you problem solving at an early age so you were not stranger to the process when you got to school. How did they do this? Do you think that you would be successful without them?
8. You say that you are not one of the "geniuses." Can you discuss what you mean by this? Who are the geniuses and why?
9. In your school, there were various academic tracks including honors and accelerated tracks. Can you explain the difference?
10. What opportunities did you see in mathematics and how did knowing this shape your persistence in mathematics?

Appendix I Sample Questions from Second Interview for Michael Brown

1. Your mom was an accountant and your dad worked for the pentagon, which were both mathematics related disciplines. Did your parents having these types of jobs shaper your early interest in mathematics?
2. You discussed how in high school you simply did mathematics as school work then you realized that engineers used mathematics in practical ways. How did you come to know this and how did it influence your decision to major in mathematics?
3. When asked what made you a successful mathematics major, you say it was the study groups. What was the nature of these groups? How did they impact you specifically?
4. You admit that most of the Black males you know were engineering majors and not mathematics majors yet mathematics is the foundation of engineering. Why do you think this is?
5. Did you receive any teacher support and encouragement in middle and high school? If you did can you describe what this support consisted of and how it impacted your success?
6. The greatest impact on your success was you keeping your motivation high even when you were fed up with your mathematics classes. Can you discuss what kept your motivation up?
7. Faith and peer support were keys to your success. How did your faith impact your success in mathematics?
8. Your science and tech high school program helped you succeed. How? What experiences did you have in this programs that was instrumental in your latter success?
9. Your expressed dismay about several of your experiences with mathematics professors. Can you elaborate on these experiences and what did you do to overcome these challenging experiences?

10. When working in your internships, you admit you had to think outside the box in order to work on the projects for which you were assigned. Can you discuss your internship experiences and whether or not they were important to your success and persistence as a mathematics major?

Appendix J Sample Questions from Second Interview for Shanice Jackson

1. You said that you had really good teacher in high school, what was good about these teachers? How did they impact your success in mathematics?
2. There were not a lot of Black students in your classes. What type of classes were you in and where were the other Black students? How did you feel about being in classes where there were few Black students?
3. Why did you choose a mathematics major? Did you consider other options? Why? Why not?
4. You mentioned in our first interview that students who have mathematics and science related majors are overachievers. Do you consider yourself and overachiever? What about your personality makes you an overachiever?
5. Family encouragement was important in your success. What types of encouragement did you receive from whom?
6. You said that your mother was an educator and made sure that you had the best education. Can you tell me what types of things she did to make sure you were successful in school?
7. You admit to not being apart of a formal study group, yet you work with some students and you guys help each other out. Can you discuss what you do to help each other and how does it support your success as a math major?
8. You admitted that you felt mathematics was hard yet you don't spend the kind of time you think you need to be successful. How do you do well anyway? What resources do you use to support your success?
9. Describe your first mathematics proof class.
10. You admit that you never really "loved" mathematics yet you did well in the disciple. How did you do this? What kept you motivated to do well even though you admit to not loving mathematics?

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