

UNDERGRADUATE AFRICAN AMERICAN WOMEN'S
NARRATIVES ON PERSISTENCE IN SCIENCE MAJORS AT A PWI

BY

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DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Educational Policy Studies
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2012

Urbana, Illinois

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ABSTRACT

While African American women are one of the largest growing populations in college, they continue to be underrepresented in science, technology, engineering, and math (STEM) fields at predominantly white institutions (PWIs) (Bowen, Chingos, & McPherson, 2009; Jordan, 2006; National Science Foundation, 2007, 2009; Warren, 1998). Some African American women depart science majors, due to school tracking or the leaky pipeline (Blickenstaff, 2005; Bowen, et al., 2009; Jordan, 2006; Oakes, 2005; Rist, 2002). Those African American women who are able to commit to hard science majors have positive self-concepts and form science identities (Gilmartin, Li, & Aschbacher, 2006; Hill, Pettus, & Hedin, 1990; Jordan, 2006). However, these ongoing problems in the previous literature serve as explanations for the underrepresentation of African American women in hard science majors at PWIs.

This multiple case research study addresses the gap in the literature on women in STEM fields by employing Black Feminist Thought (see Collins, 2000) along with the concepts of cultural capital (see Bourdieu, 1984, Yosso, 2006), commitment (Locke, Latham, & Erez, 1988), and science identity formation (see Carlone & Johnson, 2007) to examine the persistence of 16 African American women pursuing hard science majors. Using interviews and journal entries, this multiple case research study explored the differences in availability of resources, access to cultural capital, science identity formation, and adversity faced by undergraduate African American women pursuing hard science majors. The main findings from this study were that African American women who persisted in hard science majors had individual interests, support from the home environment, took high school math or science courses that aligned with Town University's introductory level math and/or science classes. They also learned how to navigate through the science curriculum and committed to the hard science major or a career in a STEM field. Forming partial science identities and having access to traditional and non-traditional

forms of cultural capital explained why some African American women remained in hard science majors as well. By overcoming adversity in the science culture, some African American women persisted and thus committed to engaging in hard science majors at Town University.

This research contributes to the field of higher education by informing policymakers and researchers about some approaches to facilitate the retention and graduation of African American women in hard science majors throughout the K-16 pipeline. Additionally, it, enriches the literature by employing multiple frameworks (e.g., Black Feminist Thought, cultural capital, science identity formation, commitment) to understand the persistence of African American women in science majors at Town University. Future research studies might examine the persistence of other underrepresented students across multiple institutions in hard science majors using qualitative and quantitative methods.

My dissertation is dedicated to those who passed away before the development of this masterpiece. So, grandma, Elizabeth McPherson, Aunt Carol Champine, grandpa Herman McPherson, Mrs. Ola Mae Lott, Mr. Leonard Lott, my mentee, friend, and sister, Ashley Nicole Thomas and all of my other ancestors. Thank you for being my supporters during your time on earth and prayer warriors as angels in the heavenly skies.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my heavenly father, my Lord and Savior for assisting me from kindergarten through the doctoral journey. In February 2008, I foresaw my *dream* committee members for the prelim and final defense as Dr. William Trent, Dr. Laurence Parker, Dr. Robin Jarrett, and Dr. Lorenzo Baber. Drs. Trent, Parker, Jarrett, and Baber, I am very appreciative for you making my *dream* become a reality! My hat goes off to my dissertation advisor, Dr. William Trent who stepped into my life at a critical period of time during the doctoral journey. I am forever grateful for your mentorship, advising, providing me with research skills through serving on research projects, and preparation of me for the academy. Dr. Parker, thank you for being an amazing advisor, mentor, and role model. When I asked you about “taking me to the finish line” during my first year of graduate school, you definitely kept that commitment. I am forever thankful for that and you encouraging me to produce scholarship through conference presentations and publications. Dr. Robin Jarrett, thank you for exposing me to qualitative research, teaching, listening when I needed to be heard, and keeping me focused on the end goal, namely graduation. Dr. Baber, I am very appreciative of you for providing me with a solid understanding of higher education research and introducing me to a network of higher education scholars. Dr. Leon Dash, thank you for teaching me the oral history tradition! Dr. DeStefano and Dr. Greene, thanks for exposing me to evaluation research through your projects.

Next, I am forever indebted to my first African American instructor, Coach Thatcher in 3rd grade, his wife Mrs. Thatcher, my first African American female instructor of 6th grade math, and my final African American secondary school instructor, Mr. Walker, who made science fun in 8th grade. My experiences in your classes definitely informed my dissertation research. I am also thankful to be exposed to school administrators like, Principal Clark at Dunbar Elementary School and Assistant Principal, Lynette Frank at Norman High School. I also give thanks to my

high school friends, Cindy, Patience, Christel, Megan and others who continued to reach their goals beyond high school and ultimately pursue a college education.

I would also like to give thanks to my University of Michigan-Ann Arbor gatekeepers, Mrs. Freeda Richardson and Mrs. Jimenez. Mrs. Freeda Richardson, thank you for allowing me to write my stories on paper in your creative writing classes. The tools that I learned from your creative writing classes helped me finish the dissertation writing in a timely manner. Then, Mrs. Jimenez, my Algebra II teacher and Stomp coach, thanks for all of your encouragement!

I am appreciative of University of Michigan doctoral scholars, now Drs. Menna Demessie and Maria Johnson for the one-hour conversation after the “Grad Connection” program which encouraged me to look at the option of graduate school. Thank you to my graduate school gatekeepers, Drs. Rowley, Countryman, Locks, Marra, Hassinger, Chaffers, and Kohn-Wood for recommending me to graduate school to obtain a master’s degree. After a conversation with the head of my department, Dr. James Anderson in the summer prior to graduate school, I decided to pursue the doctorate. Thanks for our conversations and your support, Dr. Anderson! Special thanks to my mentors, Dr. E. Royster Harper, Ayanna Triplett-McConnell, Dr. Stacey Pearson-Wharton, you rock as higher education administrators!

Then, there were my supportive bosses at the University of Michigan Office of Student Activities and Leadership, Susan, Jackie, and Dan. Thank you for building me into a stronger leader through working alongside you and offering me opportunities to grow. I enjoyed working with you and co-workers, such as Hanna Tessema and the future Dr. La’Sheanma Lumpkin who made work fun and a *home away from home*. Special thanks to my Michigan friends, Jennifer, Sabrina, Rasheeda, Akiya, Narene, Kashara, Jessica, Dominique, Shannon, Chinwe and others for thinking big and *dreaming* bigger just like me.

I am grateful for my grad school mentors, Drs. Jori Hall, Sheneka Williams, Dawn Williams, Venus Evans-Winters, Raquel Farmer-Hinton, Deirdre Cobb-Roberts, Dannielle Joy Davis, my AAP family (e.g., staff members, Dean Brown, Pam, Edna, Carla), Mildred Trent, Debbie, and Dr. Julian Parrott for supporting me during the doctoral journey as well. Thank you to my Illinois friends, Dr. Maurice Hobson, and future Drs. J. Johnson, P. Praylow, T. Wilkins, T. Laing, A. Griffith, C. Thomas, K Jones, S. Carter, D. Forbes, masters scholars, J. Roberts, B. Puryear, A. Shockley, and conference pals, Dr. F. McGaskey, future Drs. A. Butler and J. Tilghman. Special thanks to my sister and friend, Robbin who provided me with a second family in Illinois. I am proud to be godmother to your sons, my nephews Reese and Rome.

Special thanks to my University of Illinois official mentees, Samatha, Jessica, Camille, Ngozi, Kristen, Abi, my unofficial mentees, and advisees as well. Through encouraging you to pursue your educational and career goals, in hindsight I encouraged myself to do the same. My hat goes off to the *sensational 16* who are absolutely near and dear to my heart. I am very thankful for you allowing me into your lives to hear your stories of success, struggles, and perseverance in science majors in college. Thank you to my pseudomamas Renna and Sarah too!

Finally, the McPherson family, I am forever grateful to contribute to our educational legacy. Like my late grandfather, Herman McPherson said “you got to get something into your head” education. To my family members, thank you for your prayers from college throughout graduate school. Thanks to my dad for encouraging me to pursue my 6th grade *dream* of attending the University of Michigan. My experiences and exposure to people at U of M changed my life forever. Mom, thanks for teaching me that I can take lead and be the *first* person to do something. Finally, special thanks to my nephew, Archie McPherson for inspiring me to finish my doctorate to make the educational system a better place for his generation.

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION TO AFRICAN AMERICAN WOMEN IN SCIENCE.....	1
CHAPTER 2 LITERATURE REVIEW, THEORIES, AND CONCEPTS.....	20
CHAPTER 3 RESEARCH METHODS.....	68
CHAPTER 4 CASE PROFILES.....	87
CHAPTER 5 FINDINGS ON AFRICAN AMERICAN WOMEN IN SCIENCE.....	123
CHAPTER 6 DISCUSSION, IMPLICATIONS, AND CONCLUSIONS.....	194
REFERENCES.....	213

CHAPTER 1

INTRODUCTION TO AFRICAN AMERICAN WOMEN IN SCIENCE

When I was a young African American girl, I dreamed of becoming a nurse in elementary school, in part because my father worked as a nurse's assistant at the local hospital. However, I despised the thought of seeing blood and needles on a daily basis, so a career in nursing became unlikely. I was exposed to science outside of the classroom during field trips to museums and while attending science fairs at my school. My exposure to science-related activities did not encourage me to pursue nursing as a career. I lacked role models who taught science as well. By this time my father had departed the position at the hospital, and I saw few people who looked like me working in nursing. In eighth grade, I enjoyed learning science from my first and *only* Black male science instructor, Mr. Walker. He made science fun and was a role model for minority students. My subsequent high school science instructors were older White males. I was the *only* African American woman in my chemistry class during my senior year of high school. By using resources, namely the instructor and student teacher, I successfully passed the class. What remained a problem beyond the student population was the lack of mentors, role models, and teachers in the field of science who looked like me. So my dream of becoming a nurse was deferred.

College was different. A handful of female African American administrators became my mentors at the University of Michigan. In addition, I associated with a number of African American women on campus during my first year of college. They dreamed of becoming doctors, businesswomen, engineers, and lawyers, and sought other types of professional careers. I initially aspired to become a businesswoman, but I was not passionate about that field. After attending

several meetings of the University of Michigan National Association of Black Accountants, I realized that business was not for me.

Instead of taking the calculus sequence for business, I took statistics classes. The Statistics 100 instructor's accent made the lectures hard to understand. Although the Statistics 350 instructor was knowledgeable about the course materials and presented them in a way that made it easy for students to learn, family issues affected my performance in that class. I also witnessed first-hand the challenges that my friends who wanted to become doctors encountered in chemistry and mathematics classes at the University of Michigan. The aftermath of the math and science curriculum at the University of Michigan resulted in the majority of my undergraduate friends placing their dreams on hold as well. However, two college friends became doctors, two became nurses, and two obtained master's degrees in Public Health. Despite these obstacles, one friend who obtained an MPH is now pursuing a medical degree.

During my senior year I decided to pursue my educational career aspirations. In December 2005, I knew that I wanted to become a faculty member. In fact by June 2006, I was certain that I wanted to be a doctor, not a medical doctor, but earn a Doctorate of Philosophy to prepare for the professorate. As a graduate student at the University of Illinois to support my educational goals, I found mentors among the ranks of college administrators, faculty members of color, and graduate students. They facilitated my success as a first-generation graduate student by providing me with knowledge and tools that helped me navigate my way through graduate school. They helped my growth and development as a doctoral scholar at the University of Illinois. In reflection, I witnessed first-hand that some African American women depart the field of science, leaving only a small pool of African American women who were engaged in pursuing careers in the sciences.

My personal and research experiences sparked my interest in pursuing research on the persistence¹ of African American women in science majors at the college-level. My graduate school research showed me that African American women remain underrepresented in the sciences at predominantly white institutions (PWIs). The limited presence of African American women in the sciences begs the equity question of whether or not they have access to the pursuit of careers in this field given the culture of science inside PWIs. In addition, the culture of science centers on teaching science through a Western lens that privileges the contributions of White men to science from their methodologies to scientific discoveries through research (Harding, 2006). This institutional culture of science differs from the home culture of some students of color (Lee & Luykx, 2006). The result is that some students of color may feel less fit within the culture of science that centers on studying with people who do not look like them in the field of science along with being taught by White male faculty members. To further discuss the problem of the underrepresentation of African American women in STEM fields, this chapter describes the statement of the problem, the purpose of the study, the research methods, the theories and concepts that guided the study, contributions of the study to the field of higher education. It concludes with definitions of important concepts.

Statement of the Problem

As explained above, one problem within postsecondary institutions is the limited representation of African American women in science majors. Historical research revealed that African American women have always been underrepresented in the sciences and have limited mentors at PWIs (Jordan, 2006; Warren, 1998). In the present era, the leaky pipeline² and school

¹ For a definition of persistence, see the “Definition of terms” section in chapter 1.

² The “leaky pipeline” is a metaphor used to describe women leaving the science trajectory beginning in elementary school and continuing throughout college (Blickenstaff, 2005). This concept will be further discussed in chapter 2.

tracking³ may be contributing to fewer African American women successfully transitioning into science and engineering majors in college (Bowen et al., 2009; Bradley, 1997; Hanson, 1996; Jordan, 2006; National Science Foundation, 2007, 2009). Other African American women faced challenges when transitioning into these majors due to isolation, lack of academic advising and lack of a science identity (Carlone & Johnson, 2007; Johnson, 2006; Justin-Johnson, 2004; Ong, 2005; Sosnowski, 2002). The result is that the leaky pipeline might account for the underrepresentation of women and minorities in science majors beginning in K-12 schools and continuing in college, graduate/professional school and even in the workplace (Blickenstaff, 2005; Bowen, et al., 2009).

This underrepresentation of women of color in science majors may lead to them obtaining fewer science degrees. The limited number of African American women obtaining bachelors' degrees in the hard science majors contributes to the small numbers of African American women in hard science fields on the faculty level and in careers. The differences in graduation rates for college science majors results in fewer members of elite professions (e.g., social scientists, medical doctors, and scientists) being people whose race, ethnicity, and gender are not members of minority groups (Fiegener, 2009; National Science Foundation, 2007, 2009). The workforce has become segmented based on race, gender, and social class (Grotsky & Jackson, 2009).

However, some African American women have pursued hard science majors. Consider that African American women earned more degrees in STEM fields at Historically Black Colleges and Universities than from PWIs (Jordan, 2006; Perna, et al., 2009; Scriven, 2006; Warren, 1998). Research has also shown that some African American women who remain in

³ In K-12 public schools, students are placed on academic curricular tracks (high, regular, and low), which measures how well their respective high schools have prepared them for college (Oakes, 2005; Rist, 2002). This concept will be further discussed in chapter 2.

hard science majors have positive self-concepts⁴ (Hill et al., 1990). Equally as important is science identity formation⁵ (see Carlone & Johnson, 2007; Marlone & Barabino, 2008; Ong, 2005), which enables some African American women to feel confident about their academic abilities in the sciences. Science identity formation also contributes to some African American women being able to persist in hard science majors, despite obstacles that include being ignored and/or the only African American female in the classroom (Carlone & Johnson, 2007; Hanson, 2006). Other African American women complete degrees in hard science majors with family and teacher support, academic self-confidence, and a sense of belonging in the major and developing engineering identities (D. Johnson, 2007; Justin-Johnson, 2004; Montgomery, 2009; Warren, 1998). Furthermore, throughout the science educational pipeline some African American women who remained in science majors utilized forms of cultural capital⁶ such as social networks, teachers or family members (Giscombe, 2007; Jordan, 2006; Perna, et. al, 2009; Warren, 1998). Despite the successes of African American women in hard science majors, they remain underrepresented in science and engineering majors at PWIs. The next section examines the limited presence of African American women in science majors by explaining the rationale for the study.

Purpose of the Study

⁴ Self-concept is defined as how people view themselves; it can be positive or negative (Hong et al., 2003). This concept is elaborated on in the section “Definition of Terms” in chapter 1.

⁵ Science identity formation is a process that people go through in order to identify as scientist. As conceptualized by Carlone and Johnson (2007), science identity formation involves competence in science, performance using scientific methods, and your recognition and being recognized by others as a part of the science community. For a further discussion of science identity formation, see the section entitled “Theoretical and Conceptual Frameworks” in chapter 1. This concept is further elaborated on in chapter 2 as well.

⁶ Cultural capital focuses on access to resources via traditional cultural capital (see Bourdieu, 1984) and non-traditional forms of cultural capital that provide people of color with a community of wealth (see Yosso, 2006) Also see the section “Theoretical and Conceptual Frameworks” and chapter 3 for lengthier discussion of cultural capital.

The literature offers limited explanations regarding why few African American women persist in science and engineering majors. Hence, the purpose of this exploratory research⁷ is to understand the differences between undergraduate African American women who persist in hard science majors⁸ and those who transfer into social science⁹ or health science majors. It explores the question of whether there are differences in the availability of cultural capital, science identity formation, adversity due to multiple identities, and commitment to hard science majors. The current study extends the previous research by applying the frameworks of science identity formation, cultural capital, commitment, and Black Feminist Thought to better understand African American women's experiences in hard science majors. These are further discussed in the next section.

Theoretical and Conceptual Frameworks

There are a limited number of African American women in hard science majors at PWIs, so it is important to engage in an exploratory study in order to better understand why some African American women remain or depart from hard science majors, due to their multiple identities. Connected to identity, Black Feminist Thought allows Black women to share their everyday life experiences of interlocking forms of oppression based on their multiple identities (e.g., race, class, gender, nation) (Collins, 2000; Feagin & Yanick, 1998; hooks, 2000; Springer, 2005). Few researchers have applied the theoretical framework of Black Feminist Thought to

⁷ Exploratory research seeks to better “understand a phenomenon” (Krathwohl, 2004, p. 229). This type of study is appropriate, when research is “conducted to explore a new topic, to provide a beginning familiarity with that topic. This typically occurs when a researcher is examining a new interest or when the subject of study is itself relatively new or understudied” (Babbie, 1986, p. 72). Exploratory research is also used for a researcher “to test the feasibility of undertaking a more careful study” (Babbie, 1986, p. 72) and test methods to be used for a subsequent study. This method will be further explained in chapter 3.

⁸ Hard science fields of study include [but are not limited to]: biology, computer science, earth science, atmospheric science, oceanography, physical science (e.g., chemistry, astronomy, physics) (National Science Foundation, 2009). These fields are further discussed in the “Definition of Terms” section in chapter 1.

⁹ The social sciences are known as social science majors, such as anthropology, ethnic studies, history, political science, education, psychology, sociology, and linguistics (National Science Foundation, 2009). These majors are elaborated on the “Definition of Terms” part of chapter 1.

examine African American women's experiences in the sciences in post-secondary settings (Justin-Johnson, 2004). The issue of fit within the science culture becomes critical when exploring the complexity of social class for African American women in hard science majors.

In this study, social status¹⁰ is defined by parental education. Featherman and Hauser (1978) indicated that education was the best measure of social economic status and occupation. Similarly, using the 1994 General Social Survey dataset, Hauser and Warren (1997) found that “we would do better –in studies of the stratification process—to index occupations by their educational level alone than by any of the usual weighted combinations of educational level and earnings” (p. 251). So, in this research study, the participants' social status was measured by the educational and occupational attainment of their parents using the Barratt Simplified Measure of Social Status (BSMSS) scale. The BSMSS scale provides a range of scores to measure social status based on parental education and occupation (Barratt, 2006).

Social class also influences access to educational resources in schools (Lareau, 2003). Research has shown that some African American female scientists took advanced placement and honors classes in science and math, which placed them in a better position to pursue science majors in college (Jordan, 2006; Warren, 1998). Middle class and upper-income African American parents exposed their African American daughters to science experiences at home, whereas African American women from lower-class families had limited exposure to science experiences at home. Outside of the home, these women were exposed to science in classrooms, on field trips, through laboratory experiments, and at science fairs in primary and secondary schools.

¹⁰ In this proposed study, social class was assessed using demographic information sheet that asked the participants about parental income, occupation, and education. Social class is further discussed in chapter 2.

Efforts to further understand the successes and challenges of African American women in science majors in college begins within their homes and family lives, which serve as the foundation for exposure to experiences in science and math at home at an early age and in primary and secondary schools. This exposure to experiences and resources in science and math is best understood as cultural capital. Cultural capital serves as the hidden curriculum for practices inside and outside of traditional middle-class culture (Feinberg & Solitis, 2009; Bourdieu, 1984) or nontraditional cultures (see Yosso, 2006). Below is a discussion of the concept of science identity formation.

For hard science majors, Carlone and Johnson (2007) developed the science identity formation conceptual model. In this model, an individual forms a science identity when they develop competence in terms of knowledge of science. They perform by engaging in projects utilizing scientific methods. Being recognized by other scientists along with accepting oneself as a part of the science community is important to the development of an individual's science identity. Science identity literature has focused on the gender and race of women of color (see Carlone & Johnson, 2007; Ceglie, 2009), but the research omits a discussion of commitment to hard science majors together with social class.

Locke, Latham, and Erez (1988) noted that “commitment is the more inclusive concept because it refers to one's attachment to or determination to reach a goal, regardless of the goal's origin” (p. 24). In the field of higher education, women are more likely to persist in hard science majors in college if they commit to engaging in the hard science curriculum (Brickhouse, Lowery, & Schultz, 2000; Thompson & Windschitl, 2005). Commitment to hard science majors involves the utilization of resources (e.g. academic advisors, teachers, peers, family members), so cultural capital (see Banks, 2009; Bourdieu, 1984; Lareau, 2003; Yosso, 2006) is an

appropriate concept to be employed in this study. This also bridges the gap in science identity formation by including an analysis of social class.

The early conceptualization of cultural capital centered on a class-based study of the cultural tastes of members of the higher social classes (Bourdieu, 1984). However, the model omitted an analysis of race and gender (Dumais, 2002; Lareau, 2003; Lareau & Weininger, 2003; Mickelson, 2003; Yosso, 2006). It was also applied as a deficit model to explain why people of the middle class appreciated specific cultural tastes to socialize others (e.g. children, teenagers) for the middle class lifestyle while other parents lacked those cultural tastes when socializing their kids (Winkle-Wagner, 2006). Unlike previous research, using a strengths-based approach¹¹, a recent qualitative study of the persistence in college (Banks, 2009) confirmed that African American women have cultural capital (e.g., history, resources, family) which contributes to their persistence in college. Waites (2009) also found that African American families had legacies of using resources, namely family members for support for childcare and senior citizens. This is often referred to as intergenerational support. It supports the strengths-based approaches within the field of Social Work.

Using a strengths-based approach, this research study applies the framework of cultural capital to improve our understanding of the continuance of Black women in hard science majors by examining levels of resources (e.g., science laboratory tools, exposure to museums, music, art) and support (e.g., teachers, peers, and family members) they use to remain in these fields. The following section describes the research methods employed in the study.

¹¹ The strengths-based approach is drawn from the field of social work. The strengths perspective focuses on the positive attributes of individuals, family members, resources and even assets in specific environments (e.g., school, home, neighborhood) (Donaldson, Early, & Wang, 2009; Weick, Rapp, Sullivan, & Kisthardt, 1989).

Research Methods

This research is a qualitative study of the persistence of 16 African American women in science programs at a Midwestern, PWI, Town University (pseudonym). The main question that guides this research study is: Why do some African American women at a predominantly white institution persist in hard science majors while others depart from hard science majors? The subsidiary questions include:

- (1) Does forming a science identity influence the persistence of undergraduate African American women students in science majors?
- (2) Does the availability of resources impact the persistence of African American women in science majors?
- (3) Does cultural capital affect the persistence of African American women in science majors?
- (4) Do challenges based on multiple identities (e.g., race, class, gender, and ethnicity) influence the persistence of African American women in science majors?
- (5) What types of strategies do African American women use to persist in science majors?

This exploratory study employed the qualitative method of multiple case studies in order to obtain an in-depth understanding of the experiences of participants in persisting in hard science majors or transitioning into social science or health science majors. This is a topic that has been underexplored within the field of higher education. Hence, the exploratory research method is appropriate, because it allows researchers to gain a better understanding of a problem or issue for there is limited existing research (Babbie, 1986). The case study methodology complements exploratory research by enabling researchers to understand “a contemporary

phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident” (Yin, 2003, p. 13). The functions of case studies are to better understand a process that occurs in a specific case such as a person, situation, or problem (Stake, 1995; Krathwohl, 2004). The case study may confirm “a distinctive event or condition” (Yin, 2009). It is thus understandable that some cases are bounded by a specific context, such as a school or hospital (Miles & Huberman, 1994). In the case study design, Stake (1995) points out “when the case is a person, home and family are usually important contexts” (p. 63).

To add to that, the multiple case study design differs from the single case study design because it involves the replication of an experiment (Yin, 2009). Multiple case studies also involve conducting research on the same phenomenon using purposefully chosen multiple cases (e.g., people, situations, problems) to determine whether similar and/or different results are produced by studying multiple cases in the same context (Yin, 2003). The multiple case study design is appropriate when researchers want to compare and contrast findings of experiments using replication (Yin, 2009).

The multiple case research design is appropriate for this research study. This multiple case research study seeks to explore whether there are differences in career aspirations, the availability of resources, experiences in the science culture based on their multiple identities, cultural capital, identification within science communities, and strategies used by African American women who continue in or depart the hard science majors at Town University. The 16 African American women are *the multiple cases*, which are bounded by multiple contexts, including the home neighborhood, family life, and school contexts (e.g., primary, secondary, college). The family life and home neighborhood contexts are important to understanding the

multiple cases, because these contexts shaped the schools that exposed the participants to science and math experiences inside and outside of classrooms before college. These contexts may have influenced their career aspirations as well.

The multiple case study design is appropriate for the study, because it allows the researcher to better understand the phenomenon by replicating the experiment. In this study, the researcher utilized interviews with the same protocols to determine whether there are differences between the family life and home neighborhood contexts, and the school context of African American women students who remained or departed from hard science majors at Town University. The multiple case study design also leaves room for the researcher to determine whether there are variations within the group of the multiple African American women who continue to pursue hard science majors and those who left hard science majors within the institutional context of Town University.

The multiple case study design also requires that participants are purposefully chosen. In the research communities, purposive sampling is a method researchers use to “identify the purposefully selected sites or individuals for the proposed study” (Creswell, 2003, p. 185). This research involved 16 undergraduate African American women who were purposefully chosen for inclusion in this study. Eight of the participants remained as hard science majors, while the other seven participants transferred into social science or health science majors. Of that group, one African American woman was in the process of switching from health science to Chemistry, a hard science major. The recruitment of these African American women took place via e-mail through higher education administrators (e.g., Dean of the Student Success Program; Director of the Sankofa Home or student organizations). The students voluntarily elected to participate in the study by e-mailing the researcher and scheduling times to meet for the study beginning in March

2011 and ending in December 2011. The criteria for participation in the study were: (1) women who self-identified as African American or Black. (2) They were upperclassman in hard science majors or had transferred from hard science majors into health science or social science majors at Town University. (3) They were between the ages of 19 and 23. The section below describes the potential contributions of this study to higher education, the anticipated advancement of theories, and also provides policy implications.

Contributions of the Study to the Field

Substantive

This study adds to the field of higher education by extending previous research (Giscombe, 2007; Hanson, 2006; Jordan, 2006; Perna et. al., 2009) regarding the identities of African American women in science majors. It also expands our understanding of persistence (Bowen et al., 2009; Fiegenger, 2009; Perna et al., 2009; St. John, Hu, Simmons, Carter, & Weber, 2004; Winkle-Wagner, 2009). Moreover, it contributes to the field of higher education by utilizing the qualitative methodology (Giscombe, 2007; Justin-Johnson, 2004; Perna, et al., 2009) of multiple case studies to examine the experiences of African American women in the science culture in pursuit of hard science majors. Finally, the multiple case study methodology may allow scholars to better understand African American women's persistence in hard science majors at PWIs given their family and home environments. This in turn may lead to additional research studies of African American women's experiences in hard science majors at PWIs that can help address the social justice concerns of equity and access to STEM majors and careers.

Theoretical

This study extends the previous research on traditional cultural capital (e.g., Bourdieu, 1984) and non-traditional forms of cultural capital (see Carter, 2003, 2006; Yosso, 2006) and

science identity formation (Carlone & Johnson, 2007) by studying the persistence of African American women in science majors among the members of an underrepresented group in the hard sciences. It also contributes to the theoretical understanding of intersectionality (Collins, 2000) and commitment (Locke, Latham, & Erez, 1988) by examining how African American women with multiple identities made decisions to commit or forego hard science majors. Finally, the findings from this study are anticipated to contribute to our understanding of resiliency (Hill, 1997; Walsh, 1998) among African American women who remain in the hard sciences despite barriers or those who stick with the new science major of health science or social science majors.

Policy

Researchers, institutions, and policymakers can benefit from the proposed research study by obtaining a better understanding of the strategies used by undergraduate African American women to persist in hard science majors and /or transfer into social science or health science majors. The findings from this study can lead to discussions about the implementation of K-16 educational pipeline programs from primary schools through colleges to increase the engagement and retention of African American women in math and science. For PWIs, equity in STEM majors for African American women might be shown through increased graduation rates in hard science majors at the college level. This study may have the potential to address concerns about equal educational and occupational opportunities by explaining the experiences of African American women in the hard sciences, health science, or social science majors at a PWI as well. Moreover, this study has implications for addressing the underrepresentation of African American women working in STEM careers in the larger society. For example, it might be able to address the social justice issues of equity and access given the limited number African American women in the academic realm in STEM fields. This absence of African American

women role models and mentors in STEM fields has the potential to affect the pool of African American women who remain as hard science majors in college and/or pursue science related careers upon graduation from college.

Definition of Terms

In order to better understand persistence, it is important to define some key terms that will be used in the research study. In this study, college access refers to students obtaining entry to college and furthermore acquiring entry to their chosen major fields. First, college retention refers to the number of students who remain in college from one year to the next (Pascarella & Terenzini, 2005). Second, college persistence defines student success as making progress towards a degree. In this study, success by means of persistence is determined by engagement in upper-level coursework as an upperclassman (e.g., junior or senior) with an undergraduate student status. Another category of students are those who stop-out; students who stop-out “dropped out of school at some point” (Cross & Astin, 1981, p. 77). In this research study, African American women who persist in science continue to engage in a hard sciences curriculum. Female African American non-persisters in hard science majors transfer from the traditional hard science majors into social science or health science majors.

In addition, it is important to define science terminology in this section. Science can be defined as “knowledge of nature pursued by the best method of discovery and proof — the scientific method, which uses quantitative measures of physical variables” (Young, 1987, p. 31). Science is also taught from a Western perspective, which focuses on theoretical, philosophical methods, and ideologies of scientists (Harding, 2006; Lee & Luykx, 2006). The Western perspective excludes a discussion of the methods, theories, and philosophical contributions of non-Western scientists’ perspectives given their cultural values. Beyond the classroom, some researchers study science coupled with other fields of study, in which minorities and women are

underrepresented. In such research, STEM is an acronym that is used to refer to students who participate in major fields of study, such as science, technology, engineering, and mathematics (National Science Foundation, 2009).

The National Science Foundation (2009) defines the hard sciences as including: biology, computer science, earth science, atmospheric science, oceanography, physical science (e.g., chemistry, astronomy, physics). This study included business as a hard science major, because it requires a thorough understanding and application of mathematical concepts. The social science majors include: anthropology, ethnic studies, political science, economics, psychology, sociology, and linguistics (National Science Foundation, 2009). The health sciences include: community health, speech and hearing sciences, and health science. The next section provides definitions for terms describing racialized people.

The current study utilizes W.E.B. Du Bois' concept of African Americans. Du Bois defines African Americans as a group of people who have a "direct connection, in culture and race... to Africa" (Zuckerman, 2004, p. 43). Womack (2010) extends the definition of African American through her work on African American's identities after President Barack Obama's election as the first African American president after the 2008 presidential election. Barack Obama's victory created the Obama effect which is accompanied by the notion that African Americans have the opportunity to do anything (e.g., pursue degrees, occupations) as long as they put their minds to it by working hard and smart. People who identify themselves as African Americans hail from the United States and embrace the culture of Africa. The term "Black" on the other hand refers to people who hail from numerous cultures. Some people identify themselves as biracial, which encompasses two identities (Rockquemore, 2007). Others have multiracial identities, due to the genetic backgrounds of their parents. The term African

American will be used interchangeably with the term Black in this study. Some American-born Blacks consider themselves Black; others self-select their identity as being African Americans.

Similarly, if Africans, bi-racial, or multi-racial respondents self-select their identities as African American coupled with being a woman, then they are eligible to participate in the research study. The term “women of color” refers to a group of underrepresented oppressed people based on race and gender. “African American women” refers to people who identify as female and members of the African American and/or Black race. Africans are people who emigrated from the continent of Africa and maintain ties to a country in Africa. They may or may not classify themselves as being African Americans. To further understand the idea of identity, the next section discusses social psychological literature on the self.

In addition to an individual’s ethnic identity, some concepts that are connected to an individual’s ethnic identity centered on the self. Self-concept can be defined as how an individual views himself or herself based on their behavior, character traits, and/or experiences within society (Hong et al., 2003; Markus & Wurf, 1987). An individual’s self-concept is influenced by the perceptions of others regarding the individual’s behavior through social interactions within society. Bem (1967) defines self-perception as peoples’ thoughts, attitudes, and behaviors when compared to others. Another important term is self-efficacy, which involves an individual’s perception of the ability to perform a specific task (Bandura, 1997). Self-esteem is sometimes connected to self-efficacy. Self-esteem is defined as an individual’s self-worth, which includes, respect and confidence (e.g., thoughts and beliefs about the self) (Erikson, 1980).

The final concepts center on family and institutional types. The term biological kin refers to family members who have a genetic connection to the participant. Fictive kin are family

members who lack a genetic connection to the participant, but may be related based on commonalities and/or in a mentor/protégé relationship. Some families are known to be resilient. Walsh (1998) defined resilience as “the capacity to rebound from adversity strengthened and more resourceful” (p. 4). The framework of resiliency “is based on the conviction that both individuals and family strength can be forged through collaborative efforts to deal with sudden crisis or prolonged adversity” (Walsh, 1998, p. 3). Martin and Martin (1978) discussed how members of Black extended families pool their resources in order to survive in spite of obstacles. Hill (1997) also posits that “the cultural resilience of African American families headed by women is largely based on their strong achievement orientation and work ethic” (p. 111). They thrive and survive “at different stages of their life cycle because they are part of extended-family support systems” (p. 111). Additionally, single-parent, Black mothers instill education as a value and push for higher educational attainment in their children.

Finally, it is important to describe the different types of postsecondary institutions. Predominantly white institutions (PWIs) are institutions that have large proportions of whites in their student bodies, faculty, and staff (Thelin, 2004). These institutions had predominantly white student bodies when they were founded (Rudolph, 1990). These institutions comprised of majority white male students from upper class families. In contrast, Historically Black Colleges and Universities (HBCUs) are institutions where the majority of students, faculty members, and staff members are Black (Anderson, 1988). These institutions historically provided higher education to Blacks when PWIs refused admissions to Blacks. Women’s Colleges historically provided an education to women when few colleges were open to women (Solomon, 1985). The majority of the students and faculty members at women’s colleges are women. Finally, the term

minority serving institutions refers to postsecondary institutions whose majority population consists of students of color (Gasman, Baez, and Turner, 2008).

Summary

African American women continue to be underrepresented in STEM fields. To fill this gap, this study expands the previous literature on cultural capital, science identity formation, and college persistence by examining how some undergraduate African American women persist in hard science majors while others depart from hard science majors. Influences on their behavior include the availability of resources, the formation of science identities, and overcoming adversity due to multiple identities.

Organization of the Study

Chapter 1 examined the problem of African American women's underrepresentation in STEM fields, more specifically hard science majors. It also outlined the frameworks of Black Feminist Thought, science identity formation, commitment, and cultural capital, methods, and the significance of the study. Chapter 2 further examines the problem of African American women's underrepresentation in STEM fields by reviewing social science and empirical research on minorities, women, women of color, and African American women in STEM fields. It also explains the theories and concepts that will guide the research study. Chapter 3 outlines the research methods used to conduct the study and the data analysis methods. Chapter 4 describes each participant in the multiple case research study. Following is chapter 5 which reports the findings and results. Finally, chapter 6 ends with the discussion of the main findings, contributions of the study (e.g., applied, theoretical and policy), and conclusions.

CHAPTER 2

LITERATURE REVIEW, THEORIES, AND CONCEPTS

Historically both minorities and women have been underrepresented in science, technology, engineering, and math (STEM) fields across the educational pipeline (Brickhouse, 2000; Fiegener, 2009; Huang, Taddese, Walter, & Peng, 2000; National Science Foundation, 2004, 2007, 2009). It is important to review and critique the historical and contemporary literature on minorities and women in STEM fields to better understand African American women's underrepresentation in hard science majors at predominantly white institutions. To address this issue, the main question that guides this research study is: Why do some African American women at a predominantly white institution persist in hard science majors while others depart from hard science majors? Prior to answering the research question, this chapter describes the previous research methods, theories, and concepts utilized to examine the persistence of underrepresented students in STEM fields.

The first section of this chapter critiques and analyzes four bodies of research that address the issue of underrepresentation in STEM fields. This research includes the following populations: minorities, women, women of color, and African American women. The next segment discusses how the gaps in literature warrant the need for the current research study. It then describes the theories and concepts for the study. Following is the third section that comprises of the conceptual model to further explain African American women's persistence in hard science majors. The concluding part summarizes this chapter.

Persistence in Science, Technology, Engineering, and Mathematics

Minorities and STEM

The first strand of research explores the underrepresentation of minorities in the STEM fields. It first looks at degree attainment. Consider for example that quantitative research showed

that fewer minorities completed degrees in STEM fields (Anderson & Kim, 2006; Fiegner, 2009; Huang et al., 2000; National Science Foundation, 2004, 2007, 2009). Additionally, few minority students engaged in the STEM curriculum at the university level when even pursuing bachelor's degrees (Bowen, Chingos, & McPherson, 2009; Mullen, 2001; National Science Foundation, 2007, 2009). For instance, white and Asian students were more likely to major in hard sciences than their African American and Latino/a peers (Goyette & Mullen, 2006). In addition, Asian Americans were more likely to major in math, engineering, and biological sciences, followed by Blacks, whites, and Latino/a's. African Americans had the highest enrollment in all vocational majors (e.g. education, engineering, business), followed by Latino/as, whites and Asian Americans (Mullen, 2001). African American sophomores majoring in engineering, health fields, business, or computer science were more likely to persist in college than their counterparts in social sciences or undecided majors as well (St. John, Hu, Simmons, Carter, & Weber, 2004). Following is a discussion of the factors that might influence minority students' underrepresentation in STEM majors.

Explanations for departing the STEM fields. Multiple qualitative and quantitative research studies cited factors for why minority students depart STEM fields. These include (1) individual factors, (2) school factors, (3) home factors, (4) environmental factors, and (5) limited understanding of careers in STEM fields.

First, individual factors accounting for minority students' departure from STEM fields include: stereotypes about the intellectual capabilities of minority students. Consider for example that some students of color who internalize stereotypes from peers and instructors about their intellectual abilities, isolation, prejudice, and racism in the classroom switched from science, math, and engineering (SME) majors to social science majors (Seymour & Hewitt,

1997; Wilson, 2000). In college, some minority students' peers might feel as though they are less capable of engaging in math, science, or engineering problem solving in class (Wao & Lee, 2010). Additionally, reducing stereotype threat might in fact increase exam performance, especially for Black students (Steele & Aronson, 1995), and thus change their attitudes and perceptions about math and science school curriculum.

Second school factors influence minority students' departure from STEM fields. Such factors include academic preparation, the leaky pipeline, and access to laboratory resources. Consider that school tracking throughout the educational pipeline limited students of colors' access to advanced math and science classes (Clewell, Anderson, & Thorpe, 1992; Clewell & Braddock II, 2000; Oakes, 1990, 2005; Rist, 2002). Hence, some student of colors took fewer college preparatory math and science classes than their white peers (Heppner, Wao, & Lee, 2010). This might have caused them to experience academic challenges when taking science, mathematics, and engineering (SME) classes at the undergraduate level as well (Heppner et al., 2010; Seymour & Hewitt, 1997; Tyson, Smith, & Ndong, 2010). As a result some students of color switched from the SME major to social science majors (Seymour & Hewitt, 1997, Tyson et al., 2010).

Similarly, research studies indicate that the leaky pipeline begins in primary schooling and continues from college to careers in STEM fields (Blickenstaff, 2005; Clewell et al., 1992). From kindergarten through third grade, differences in mathematical achievement by race (e.g., the Black-White gap) might be due to differences in cognitive development, socioeconomic status, residential and school segregation. Similarly in middle school, minority students, Black and Latino students scored lower than their white peers on the mathematical and science sections of the National Achievement Educational Progress (NAEP) tests (Clewell et al., 1992; Clewell &

Braddock II, 2000). This might be attributed to differences in learning styles, teacher expectations, their attitudes (e.g. enjoyment) and perceptions (e.g. utility of the curriculum to their culture) regarding math and science (Clewell et al., 1992; Clewell & Braddock II, 2000). Additionally, in high school, some minority students have limited exposure to laboratory experiments and science or math-related activities outside of the classroom when compared to some of their white peers (Clewell et al., 1992). Students of color might be enrolled in fewer advanced math and science classes and take fewer science and math classes than their white peers as well. This lack of academic preparation might hinder their success in STEM majors in college.

Third, home factors, such as limited role models and parental expectations influence the performance of minority students in math and science classes (Clewell et al., 1992; Clewell & Braddock II, 2000). Fourth the environment or rather STEM culture causes some minority students to leave STEM fields. Consider the fact that some minority students who feel isolated in SME classrooms were less likely to persist in science fields in college (Seymour & Hewitt, 1997; Tyson et. al, 2010; Wao & Lee, 2010; Wilson, 2000). Students with fewer interactions with peers and faculty members were less likely to remain in STEM fields as well (Alfred et al. 2005; Tyson et al, 2010 2010; Wao & Lee, 2010; White, Altchuld, & Lee, 2006). Minority students with challenges with STEM curriculum in college were also more likely to depart the hard science major as well (Tyson et al., 2010; Wilson, 2000). Furthermore, minority students with less engagement in curriculum and programs were more likely to depart STEM fields (Alfred et al. 2005; White et al., 2006). As a result, fewer minority students have opportunities for success in pursuing degrees in STEM fields.

Similarly in the STEM culture, teaching and learning within the field through a Western mode of thought might sway minority students to forsake STEM majors. For instance in the teaching of science, students learn about the contributions of Western scientists and less about the ideas and thoughts of non-Western scientists (Harding, 2006; Lee & Luykx, 2006; Seiler & Gonsalves, 2010). Hence, these researchers advocate for a culturally relevant pedagogy to encourage the studying of nonwestern modes of thought and to furthermore increase the engagement of underrepresented students in the field of science. This culturally relevant instruction might involve science materials utilized by African Americans including everyday items (e.g., cell phones) or activities (e.g., roller coasters) and science materials that they see in their real-life experiences, such as the street life culture, and hair care products (Seiler, 2001). It might focus on changing the power structures from lecturing to student-centered learning and teaching in science classrooms to apply real-life examples to help women or minority students learn and engage more in the science curriculum as well (Busch-Vishniac & Jarosz, 2007; Heppner et al., 2010; Lee & Luykx, 2006; Seiler & Gonsalves, 2010).

Implementing appropriate programming in schools might be beneficial to improve the retention and persistence of students of color in STEM fields (Alfred et al. 2005). Research also confirms the importance of curriculum for minority students committed to pursuing biomedical and behavioral sciences (Hurtado et al., 2007). However, limited research described the implementation of culturally relevant pedagogy in college classrooms.

Equally as important, the STEM-switching culture is another environmental factor that results in the underrepresentation of minorities in STEM fields. For instance, research showed that some minority students who elected a STEM field as the first major transitioned into majors outside of hard sciences (Goyette & Mullen, 2006; Heppner, 2010; Leslie, McClure, & Oaxaca,

1998; Tyson et al., 2010; Wao & Lee, 2010). More importantly, of those who successfully completed STEM degrees, a higher percentage of minorities completed bachelors' and advanced degrees in biological sciences (Lewis, Menzies, Najera, & Page, 2009). However, what remains a problem with this research is a limited understanding of the experiences in the STEM culture that caused minority students to depart the STEM fields.

Finally, the lack of knowledge about SME related careers might result in the underrepresentation of minority students in science or math-related careers. Consider for example middle school minority students who were unaware of the utility of math or science were less likely to want take science or math curriculum in middle school let alone pursue careers in these fields (Clewel et. al, 1992). In college, some minority students who switched from SME majors to other majors did not fully see themselves in a career in engineering (Tyson et. al, 2010). They also had limited knowledge on what they could do with engineering degrees.

Explanations for remaining in STEM fields. In addition to the literature on minority students' departure from STEM fields, another body of literature highlights the reasons for minority students remaining in STEM majors. This qualitative and quantitative literature attributed minority students' persistence in STEM fields to individual, school, and home factors.

One individual factor that contributes to minority students' retention in STEM fields is motivation. Research showed that minority students with lower high school grades in science and math and the SAT math scores might be intrinsically motivated to do well in math and science (Smyth & McArdle, 2004). Hence, they might be successful in SME majors in college. Social psychological research points to self-perception as a factor that might explain minority students' continuance in STEM fields. Consider for example that minority students' high self-concepts, self-esteem, and academic self-confidence positively influenced their persistence in STEM

majors (Alfred et al., 2005; Clewell & Braddock II, 2000; Wilson, 2000). In middle school minority students who did well in science and math had high academic confidence in their academic abilities in these subjects as well. Hence, it was no coincidence that these minority students later took higher level math and science courses.

Social psychological research suggests that a sense of belonging in the science culture is another factor that explains why some minority students persist in the STEM culture. Access to research projects coupled with building relationships with faculty members positively impacted the persistence of underrepresented students in science majors (Alfred et al., 2005; Anderson & Kim, 2006). Minority students might feel a sense of belonging by participating in the research community and by taking math classes with a culturally relevant approach.

School factors including: interactions with peers, mentors' encouragement, and support were also vital to the persistence of minorities in SME majors in college. Consider for example that students of color who persisted in the SME major received academic support (e.g., tutoring, departmental advising), learned about financial aid, and peer support by way of study groups (Seymour & Hewitt, 1997). Some students of color who participated in research with faculty members, peer support, or mentor were more likely to remain interested in pursuing careers in biomedical or behavioral sciences as well (Alfred et al., 2005; Oseguera, Hurtado, Denson, Cerna, & Saenz, 2007).

Finally, home factors such as parental or family support influenced the persistence of some minority students in STEM fields. For instance, some high school minority students might continue to pursue their desired majors in physical sciences or engineering as a result of family support (Gilmartin et al., 2006; Hurtado et al., 2007; Tyson et al., 2010). Similarly, parental encouragement, cultural values, socialization, peer support, and role models influenced students

of colors' participation and retention in SME curriculum from primary school throughout graduate school and even their careers (Clewell & Ginorio, 1996; Tyson et al., 2010).

Summary of Research on Minorities in STEM Fields

In sum, results from quantitative research on minorities indicate that there continues to be a problem of underrepresentation of minority students in STEM majors in college. A combination of quantitative and qualitative research attributes this underrepresentation to individual factors (e.g., stereotypes), school factors (e.g., academic preparation, school tracking, interactions with peers and faculty members), home factors (e.g., parental expectations, limited role models). The environment, namely the STEM culture and the limited knowledge of careers results in fewer minority students engaging in STEM majors in college. In contrast, individual factors (e.g., intrinsic motivation, self-confidence, self-perception), school factors (e.g., peer support, academic support via tutoring, research with faculty members), and home factors (e.g., family support, role models) explained why some minority students stayed in STEM fields.

Equally as important are the gaps and holes in the literature on minority students' persistence in STEM fields. First, the individual factors research is limited in determining if minority students internalized stereotypes about performance in math and science in primary, and secondary schools. Second, for school factors, few researchers examined interactions with peers and instructors in math or science cases in primary and secondary schools. Third, the research on home factors is outdated and few researchers examined this factor to address why some minority students leave STEM fields. Fourth, there is limited research on how the science and math culture in primary and secondary schools influenced minority students' subsequent departure from STEM majors in college. Fifth, few researchers have examined how individual factors (e.g. intrinsic motivation, academic confidence) in elementary school and college resulted

in minority students' continuance in STEM fields. Sixth, limited research explored how school factors (e.g., academic support, peer support, teacher support), home factors (e.g., family support, role models), and career aspirations positively influenced the persistence of minority students in STEM fields.

To add to that, this strand of research does not account for the differences in the underrepresentation of minorities in STEM fields based on gender or social class. Hence, without an intersectional perspective, this research lacks an in-depth understanding of the problem of underrepresentation for both men and women with similar or different racial/ethnic and social class backgrounds that leave or remain in STEM fields. The next section describes the ongoing debates about women who continue or leave STEM majors.

Women and STEM

The second strand of literature on underrepresented populations in STEM is centered on women. This literature focused on engagement and attrition throughout the educational pipeline. For example quantitative research confirms that women's enrollment, persistence, and graduation from college continued to increase from the 1970s throughout the new millennium (Peter, Horn, & Carroll, 2005). However, more women majored in education, communications, and professional programs than their male counterparts (Bowen et. al, 2009). Fewer women earned bachelors, masters, and doctoral degrees in STEM fields as well (Fiegener, 2009; NSF 2007, 2009). Furthermore, the women who continue to pursue STEM as a major are more likely to major in math, physical and biological sciences than their male counterparts (Mullen, 2001; Britner, 2008). They are less likely to major in engineering like their male peers (Bowen et al., 2009; Mattis, 2007; Mullen, 2001).

Explanations for departing the STEM Fields. The leading factors for women's departure from STEM fields in qualitative and quantitative research are: (1) individual, (2) school, (3) home, (4) environmental, and (5) fit in careers. Following is a more in-depth discussion of the literature on these attrition issues for women in STEM fields.

First, social psychological literature points to self-efficacy as an individual factor that might explain why there are fewer women in science and engineering majors. Consider for example that low confidence in research lab abilities coupled with performance in science and math classes resulted in women departing from science fields (Astin & Sax, 1996; Clewell et al., 1992; Hall, 2007; Hughes, 2000; Micari, Pazos, & Hartmann, 2007). Stereotype threat is another factor that influences the underrepresentation of women in STEM.

Consider that some girls might perform lower on math or science exams due to hearing stereotypes of women being less academically capable in those subjects (Aronson, 2009; Blickenstaff, 2005; Clewell & Campbell, 2002; Levy & Kimura, 2009; Seymour & Hewitt, 1997; Steele, Reisz, Williams, & Kawakami, 2007; Wao & Lee, 2010). Gender roles are another individual factor that discourages girls from engaging in science and math in K-12 schools throughout careers due to being nurturers. Similarly, in college women might be seen as less capable of engaging in math, science, or engineering curriculum by their male peers (Hall, 2007; Lee & Wao, 2010; Mattis, 2007; Steele et. al, 2007). Females entering male-dominated fields like engineering may be seen as masculine thus stereotyping women as less feminine in these fields (Faulkner, 2010). This might lead to some women departing from STEM fields.

Second, school factors that impact the underrepresentation of women in STEM fields are the leaky pipeline and academic preparation. Blickenstaff (2005) describes the leaky pipelines as a process in which women drop out of the STEM fields from elementary school throughout

college and even when pursuing careers. Hence, the leaky pipeline results in “a sex-based filter that removes one sex from the stream and leaves the other to arrive at the end of the pipeline” (Blickenstaff, 2005, p. 369). These include: the gender achievement gap in math and science and differences in course-taking patterns in math and science (American Association of University Women, 1992; Heppner et al., 2010). Of the high school girls who enrolled in advanced placement courses, fewer took advanced placement exams in computer science, calculus, or physics (Burke, 2007; Clewell & Campbell, 2002). Other factors for women’s underrepresentation in STEM fields might be biological differences in innate abilities, early experiences, curriculum, and teaching style (Kaplan & Rogers, 2001; Levy & Kimura, 2009).

Third, the home environment impacts women and girls’ underrepresentation in STEM fields. Parental socialization influences girls and women’s engagement in STEM majors. Early socialization based on gender roles might result in girls playing with dolls instead of video games or other forms of technology (Burke, 2007; Clewell et al., 1992; Han, Sax & Kim, 2007; Heppner et. al, 2010). Some girls receive less encouragement from their parents to pursue science or engineering in college or as careers as well (Burke, 2007; Clewell et. al, 1992; Hall, 2007; Han et al., 2007; Heppner, Lee, & Wao, 2010; Leslie et. al, 1998; Mattis, 2007, Tang, 2006). This might be rooted in gender biases due to biological differences, which relegate women to roles as nurturers (Hall, 2007; Levy & Kimura, 2009; Tang, 2006). Role models are another home factor influencing girls and women’s departure from STEM fields. Some girls might take fewer math and science classes due to the lack of female role models (Burke, 2007; Hall, 2007; Heppner et. al., 2010; Leslie et al., 1998). So it is understandable that fewer women major in science and engineering fields at the undergraduate and graduate level.

Fourth, environmental factors account for the underrepresentation of women in STEM fields. Some girls felt unwelcome in science classes due to the chilly climate (Clewell & Campbell, 2002; O'Callaghan & Jerger, 2006). Social psychological literature also points to an ill-fit in the science culture contributing to fewer women in science and engineering majors. Consider for example that women who felt invisible and unwelcome in class were less likely to continue pursuing a degree in science (Tonso, 1999; Han et al., 2007). The chilly climate of research laboratories in science resulted in the attrition of women in science as well (Burke, 2007; Confrey, 2000; Ferreira, 2002; Hall, 2007). Equally as important, in graduate school math departments, some women lacked mentorship and felt invisible with limited guidance and interactions with their advisors (Herzig, 2004; Steele, et al., 2007). The teaching style in mathematics was incompatible with their learning style, which impacts their ability to fully understand the materials. This resulted in some women wanting to be in a community space in math with caring instructors who provide feedback on assignments and serve as mentors. So, there was a critical need for role models and mentors to encourage girls and women to persist in the math and science pipeline (Burke, 2007; Hall, 2007; Mattis, 2007; O'Callaghan & Jerger, 2006; Virnoche, 2008; Wao & Lee, 2010; Whitten et al., 2007).

Researchers also proposed changing the research lab climate (Burke, 2007; Confrey, 2000; Ferreira, 2002; Hall 2007) and curriculum and pedagogy (Brotman & Moore, 2008; Burke, 2007; Hall, 2007; Larsen & Stubbs, 2005; Wao & Lee, 2010) in science and engineering majors to retain women scholars. The curriculum might include more hands-on learning for women in college (Hall, 2007). To address the attrition problem of women in graduate school, some institutions have created retention programs to increase the number of women persisting in

science, engineering, and math majors (Bozeman & Hughes, 2004; Hathaway, Sharp, Davis, 2001; Mattis, 2007).

Finally, a plethora of research focused on the underrepresentation of women in careers in STEM fields due to the work environment. This might be due to limited role models and mentors, opportunities to conduct sole research and serve on research projects with male counterparts (Blickenstaff, 2005; Burke, 2007; Hall, 2007). Research also points to the underrepresentation of female faculty members due to balancing work and families (Burke, 2007; Hall, 2007; Mattis, 2007; Rosser & Daniels, 2004; Rosser & Lane, 2002; Tang, 2006). In these fields of study, some women sacrifice engaging in the traditional role of being nurturers in service work to engage in work in a masculine field of study, which devalues femininity (Faulkner, 2010; Hall, 2007; Madill et al, 2007). Discrimination and sexual harassment reduced the number of women in science and engineering as well (Burke, 2007; Faulkner, 2010; Gunter & Stambach, 2005; Hall 2007; Rosser & Lane, 2002). Isolation, stereotypes about performance, limited mentorship, and credibility as researchers also accounts for fewer women in science and engineering careers (Rosser & Lane, 2002). Hence, the chilly climate from gender bias, discrimination, isolation inside of departments and laboratories results in fewer women scientists and engineers (Burke, 2007; Gunter & Stambach, 2005; Hall, 2007; Rosser & Zieseniss, 2000). From this section, there appears to be a limited application of a K-16 pipeline approach to understand why some girls and women leave STEM fields.

Explanations for remaining in STEM Fields. An opposing view of the aforesaid research explains the reasons why some women remain in STEM fields. Qualitative and quantitative research attributed persistence in STEM for women to (1) individual factors, (2) school factors, (3) home factors, (4) environmental factors, (5) career aspirations and retention.

First, an individual factor, self-motivation accounts for girls' engagement in science and math classes. Consider for example that connections of science to people result in some girls higher grades in these subjects beginning in middle school, because they might be self-motivated to do the work and turn it in on time (Britner & Pajares, 2001). In high school, some females refuse to accept gender stereotypes regarding academic performance and participation in advanced math and science curriculum (Corra, 2007). Motivation and high-self efficacy might play an instrumental role in high school girls' engagement in life, physical, and earth sciences as well (Britner, 2008). Similarly, women might do better in college engineering classes and labs if they exert more academic confidence when engaging in the labs and course assignments, especially when working with their male peers (Huang et al., 2000; Micari et. al., 2007). Other females felt very confident in science, math, or technology courses with males in their same majors (Hughes, 2000).

School factors also explained why some girls and women remain in STEM fields. Teachers and school counselors encouraged some high school girls to pursue math and science as well (Clewel & Campbell, 2002; Parrott, Spatig, Kusimo, Carter, & Keyes, 2000; Weisgram, & Bigler, 2006). Additional research recommends that high school teachers to encourage girls to feel more confident and engage in science in summer programs (Ginorio, Huston, Frevert, & Siebel, 2002). Furthermore, the home environment influences girls and women's engagement in STEM fields. Family members can encourage girls to pursue math and science at an early age through socialization (Hall, 2007; Leslie et al., 1998). In science and engineering, women's support consisted of financial and emotional support from parents, many of which were college educated (Huang et al., 2000). Similarly, home factors such as role models and mentors can increase women's engagement and persistence across the science pipeline (Astin & Sax, 1996;

Hall 2007; O'Callaghan & Jerger, 2006; Virnoche, 2008; Whitten et al., 2007). These factors might encourage women to pursue careers in STEM fields as well (Williams & Emerson, 2008).

Equally as important is the environmental factor of forming a science identity for girls and women who continue in the educational pipeline in STEM fields. Girls and women engaging in science develop a personal connection and commitment to engage in the subject matter, known as a science identity (Brickhouse, Lowery, & Schultz, 2000; Thompson & Windschitl, 2005; Brotman & Moore, 2008). Other girls and women might develop engineering identities and further commit to engaging in the engineering curriculum (Heyman, Martyna, & Bahatia, 2002). However, what is absent from this literature is a full understanding of the experiences as told by women and girls of how they formed identities in STEM fields.

Finally, a handful of articles examine the factors leading to women's retention in careers in STEM fields. Early on, women interested in becoming scientists enjoyed asking questions and problem solving (Davis, 1999; Hall, 2007). Teachers also socialized them women for science careers by allowing these women to construct their own research projects or solve problems (Davis, 1999). Barriers such as sexism, stereotyping and biases accounted for some women faculty members desire to pursue a career as scientists. Furthermore, mentoring, multiple teaching methods, and role models might result in some women continuing in science and engineering careers (Hall, 2007; Madill et al, 2007; Mills, Ayre, & Gill, 2010; Williams & Emerson, 2008). Job satisfaction among spouses, work environment, and recognition accounted for women faculty members balancing work life and careers as well (Amelink & Creamer, 2007). This might encourage them to remain in male-dominated careers in science and engineering fields.

Summary of Research on Women in STEM Fields

In conclusion, quantitative research show that few women completed degrees in STEM fields compared to their male counterparts. There are multiple reasons why women depart STEM fields. These include individual (e.g., stereotypes, self-efficacy, self-confidence, perceptions of careers), school (e.g., academic preparation, the leaky pipeline), home (e.g. limited role models, lack of parental encouragement), environment (e.g. chilly climate, teaching style), and careers (e.g. work environment). Similarly research documented the reasons why some women remained in STEM fields. Individual factors of self-motivation, academic confidence, and real-life applications and school factors, teachers and school counselors encourage girls and women to stick with STEM across the educational pipeline. Home factors (e.g. family, financial, role models), the environment, STEM culture (e.g., science identity formation), and career aspirations explained why some women stayed in STEM fields.

Equally as important are the gaps and holes in this strand of research. First, there are limited explanations for how the home environment influences girls and women's departure from STEM fields in high school and college. Few researchers accounted for the impact of the home environment on the persistence of girls and women in science and math in primary and secondary schools. Additionally, research is limited in explaining why some girls engage or disengage from science and math classrooms throughout the educational pipeline. Furthermore, by only focusing on women's experiences there are limited understandings of differences in experiences of women, especially women of color. Following is a discussion of the literature on women of color that describes the factors resulting in their departure or continuance in STEM fields.

Women of Color and STEM Fields

The third strand of research focuses on the underrepresentation of women of color in STEM fields. Similar to the aforesaid research on women, a plethora of research confirmed that women of color continue to be underrepresented in STEM fields (Carlone & Johnson, 2007; Clewell & Anderson, 1991; D. Johnson, 2007; National Science Foundation, 2004, 2007, 2009; Ong, 2005; Seymour & Hewitt, 1997). In addition to gender, women of color have to deal with multiple identities of race and social class when navigating through STEM majors. What follows is a discussion of the leading debates about why they remain or leave STEM fields.

Explanations for departing the STEM Fields. Some explanations for few women of color in STEM fields are based (1) individual, (2) school, and (3) the environmental factors. First, an individual factor, self-perception explains why few women of color participate in STEM fields. Barriers to girls of color and women of color's participation in math and science revolve around their attitudes and perceptions in contexts such as school and home (Clewell & Anderson, 1991; Clewell & Ginorio, 1996). Some individual factors that explain their departure from STEM fields includes: stereotypes about gender roles and how the fields are dominated by boys and men. Additionally, perceptions about the utility of math and science in everyday experiences, self-confidence and self-concept influence whether or not they continue to pursue science or math.

Second, school factors account for the departure of some girls of color and women of color from STEM fields. These include representation in textbooks, peers' participation in science and math, teachers' encouragement or discouragement (Clewell & Anderson, 1991; Clewell & Ginorio, 1996). The leaky pipeline is another school factor for women of color leaving hard science majors. According to Johnson (2006) "the image of the leaky pipeline is often used to explain the absence of women of color in the cadre of practicing scientists" (p.

136). She continues “this image suggests that girls and boys of all races begin school curious about the world around them—eager and ready to learn about science” (Johnson, 2006, p. 136).

Course curriculum is another school factor that results in some girls of color departing from STEM fields. In high school, some girls of color are less likely to enroll in advanced science and math classes as well (Ceglie, 2009; Clewell & Ginorio, 1996).

Third, home factors explain for women of color forsaking engagement in STEM fields. Home factors include less socialization at home, parents’ expectations, exposure to extracurricular activities via parent, and role models (Clewell & Anderson, 1991; Clewell & Ginorio, 1996). In addition girls of color have few role models in math and science and less access to computers than white females in primary schooling (Clewell & Ginorio, 1996). Finally, the environment, namely the science culture (e.g., teaching, pedagogy) might account for fewer women of color pursuing degrees or careers in STEM fields. In college, women of color might feel discouraged to pursue science majors due to the lecture style classes taught by professors, or professors who are unavailable to assist them with the curriculum, and challenges on multiple choice exams (A. Johnson, 2007). As a result, fewer women of color might engage in physics (Ong, 2005). Hence, it was understandable that fewer African American women and Latinas earned bachelors’ degrees and advanced degrees, especially doctorates in physics as their white female peers (Bowen et al., 2009; Ong, 2005).

Explanations for remaining in STEM Fields. To counter the rationale for women of color’s departure from STEM fields, a growing body of literature describes their reasons for staying. These include: (1) individual factors, (2) school factors, (3) home factors, (4) environmental factors, and (5) career aspirations.

First, social psychological literature points to sense of belonging in science communities as an individual factor accounting for women of color remaining in STEM fields. Peer support and a sense of belonging influences women of color to remain in science majors as well (Ceglie, 2009; D. Johnson, 2007). Interactions with peers and faculty members impacts women of color remaining in science due to feeling a sense of belonging (D. Johnson, 2007). Research also shows that women of color debunked the stereotypes (e.g. laziness, inferiority) about their abilities and identities in physics, which accounted for some women of color's invisibility and underrepresentation in the field of science (Ong, 2005). By passing as scientists, they used the strategy of acting white by ignoring their ethnic identities. They are also assertive and asked questions in the classroom. This suggests that they might have acted the opposite of their race and gender identities to do well in physics. They also have positive thoughts about the campus racial climate (D. Johnson, 2007).

Second, school factors explained why more women of color persisted in STEM fields. Consider for example that women of color who took advanced science classes, participated in academic enrichment science programs, and research opportunities with faculty members remained in science at the undergraduate level (Ceglie, 2009). Women of color who persisted in science majors in college held high academic confidence in college science curriculum as well (D. Johnson, 2007). Additionally, peer support and school programs encouraged women of color to remain in college science programs (Ceglie, 2009). Some faculty members support some women of color by allowing them to engage in the research programs, internships, and volunteer opportunities as well. This in turn positively influences their persistence in science majors. It might cause them to form science identities. Some developed these identities while pursuing the science majors and even in pursuit of their career aspirations.

Third, the home environment, more specifically family support positively influenced women of color's persistence in STEM fields. For instance, financial support from families and parental support resulted in the persistence of some women of color in science at the undergraduate level (Ceglie, 2009; Johnson, 2006). Women of color from religious families attributed spirituality and religion to their continuance in science majors in college as well (Ceglie, 2009). Fourth, the environment, namely the science culture impacted women of color's persistence as well. Women of color who held "research scientist identities are working on or have completed doctorates in science; all those with altruistic scientist identities are working on or have completed graduate work in health professions" (Carlone & Johnson, 2007, p. 1209). These women of color's success in science can be attributed to identifying as research scientists and forming relationships with "professors who recognized them as capable science students and gave them access to relevant scientific activities" (Carlone & Johnson, 2007, p. 1210). Other women of color "whose recognition as scientists was disrupted are pursuing degrees or careers in science-related fields" (Carlone & Johnson, 2007, p.1209). Finally, career aspirations might account for some women of color remaining in STEM fields. Some college women of color who persisted enjoy science and aspired to engage in service-oriented careers as well (Johnson, 2006).

Summary of Research on Women of Color in STEM Fields

To sum up, quantitative and qualitative research shows that women of color are underrepresented in STEM fields. Some explanations for their departure include: individual (e.g., stereotypes), school (e.g. academic preparation, curriculum, the leaky pipeline), home (e.g., socialization, parental expectations, limited role models), and the environment (e.g. teaching, pedagogy). Additionally, some women of color remain in STEM fields due to multiple factors. These include individual (e.g., sense of belonging, debunking stereotypes), home (e.g., family

support, religion, spirituality), environment (e.g., science identity formation), and career aspirations.

Furthermore, it is important to explain the gaps and holes in this strand of research. First, the literature on individual factors is dated, so there is a need for current explanations on individual factors influencing the departure of women of color from STEM fields. For women of color who persist in STEM fields, the literature on individual factors only focuses on college women. So there is a gap in knowledge on the impact of individual factors on girls of color's interest in STEM fields in primary and secondary schools. Second, there is a limited understanding on the school factors in elementary and middle school that influence girls of color's later persistence in STEM fields in college.

Third, the literature on the connection of the home environment to girls of color and women of color forsaking STEM fields is outdated as well. Scholarship on women of color who remain in STEM fields does not account for the connection of the home environment in primary and secondary school that might have influenced their later continuance in STEM fields in college. Fourth, there is only a small body of research explaining the influence of career aspirations or commitment to careers on women of color's departure from STEM fields. Equally as important, from this research it is apparent that women of color have slightly different experiences in STEM fields due to their raced and gendered identities. However, by lumping African American women into the category of women of color, researchers gain a limited understanding of the heterogeneous experiences of African American women who engage or disengage in STEM from primary schools throughout careers. The next section attempts to fill this gap in literature by describing research on African American women in STEM fields.

African American Women in STEM Fields

The fourth strand of research critiques and analyzes the problem of underrepresentation in STEM fields for African American women. Understanding the persistence issues of African American women in STEM fields begins with their historical underrepresentation in access to opportunities to engage in STEM majors in college. This section begins with a discussion of their historical underrepresentation in STEM fields. It then describes debate and issues of retention and persistence of African American women in modern times.

Historical Insight on Underrepresentation in STEM Fields. There is a plethora of historical research that attributes the underrepresentation of African American women in STEM fields to degree attainment. In the beginning of the 20th century, few Black women engaged in chemical sciences curriculum in college (M. Rayner-Canham & G. Rayner-Canham, 1998). The majority of Black women received doctorates in education between 1921 and 1954 (Evans, 2007). In addition, only a few Black women earned medical degrees and doctoral degrees in science and mathematics from predominantly white institutions (PWIs). Some of these institutions included: New York University, University of Kansas, University of Michigan, University of California Los Angeles, and University of Toledo (Warren, 1998). Private PWIs that Black women attended were Columbia University, Emory University, George Washington University, Georgetown University, Stanford University, University of Chicago, University of Pennsylvania, and Vanderbilt University.

Furthermore, some PWIs produced the first African American doctors in American society in the 20th century (Warren, 1998). For instance, Cornell University produced doctors including: a physician, Dr. May Edward Chin in 1926, physiatrist and researcher, Margaret Morgan Lawrence, physician, F. Pearl McBroom in 1954, physician and the first Black woman

astronaut, Mae Jemison in 1984. Similarly New York Medical College produced an African American graduate, Jane Cook Wright who obtained a medical degree in 1945. A few years later, her sister, Barbara Wright Pierce procured a medical degree from Columbia University. In 1948, Margaret E. Grigsby earned a medical degree from the University of Michigan. During the same year, an exception to the rule, Dorothy Lavinia Brown became the first Black woman in the South to acquire a medical degree at the predominantly Black institution, Meharry Medical College in Tennessee.

In addition to the medical sciences, PWIs produced a small number of Black women doctorates in STEM fields. For instance, in 1933, Ruth Ella Moore was the first Black woman to earn a natural science doctoral degree from an American institution, Ohio State University (Warren, 1998). A year later, in 1934, Ruth Winifred Howard was the first Black woman to earn the doctorate in psychology from the University of Minnesota. Another Black woman, Roger Arlinger Young received a Ph.D. in biology from the University of Pennsylvania in 1940 (M. Rayner-Canham & G. Rayner-Canham, 1998). Three years later in 1943, Euphemia Lofton Haynes was the first Black woman to secure a doctorate in mathematics in American society from a Catholic university (Kenshaft, 2005). Marie Maynard Daly was the first Black woman to obtain a doctorate in chemistry in 1948 from Columbia University (Warren, 1998).

Less than a year later, Marjorie Lee Brown earned the first doctorate in mathematics from the University of Michigan in 1949 (Warren, 1998). Evelyn Boyd Collins Granville obtained a doctorate in mathematics in 1950 from Yale University (Jordan, 2006). Twenty-five years later, in 1973, Shirley Ann Jackson became the first Black woman to obtain a doctorate in physics from Massachusetts Institute of Technology and in American society. In fewer than five years, Giovonnae Anderson Dennis received a doctorate in electrical engineering from the University

of California-Davis in 1978 while Jennie R. Patrick earned a PhD from MIT in engineering in 1979. In 1983, Geraldine Claudette Darden obtained a doctorate in mechanical engineering from George Washington University. In sum, this research confirmed that few African American women earned advanced degrees in STEM fields in the 20th century. Hence, the historical underrepresentation of African American women in STEM fields might account for the production of fewer African American women in STEM fields due to limited role models and mentors. What follows are some recent debates about the underrepresentation of African American women in STEM fields.

Current Explanations for Underrepresentation in STEM Fields. The current underrepresentation of African American women in scientific fields might be connected to their historical underrepresentation in science majors. Throughout the 1960s, 1970s, and in the 1980s, only a few African American women earned degrees in the sciences, especially from HBCUs (Scriven, 2006). However, Black women remained underrepresented in scientific degrees and careers (Jordan, 2006; Warren, 1998). Similarly, in the modern day, quantitative research confirmed that fewer African American women participating in STEM fields (Bowen et al., 2009; National Science Foundation, 2007, 2009). Despite the increases in Black women's participation in higher education, few Black women obtained doctorates in science, math, and engineering.

Additionally, quantitative research showed that African American women continue to be underrepresented in obtaining bachelors and advanced degrees in earth science, atmospheric science, oceanography, physical science, agriculture, and biology (Bowen et al., 2009; National Science Foundation, 2007, 2009). More importantly, in college African American women elected biological sciences as the first college major more than their African American male

counterparts (Goyette & Mullen, 2006). Only a few African American women obtained doctorates in STEM fields (Jordan, 2006; National Science Foundation, 2004, 2007, 2009). The underrepresentation of African American women in scientific fields might result in their limited presence in scientific careers as well. Following are some reasons why some African American women leave or stay in STEM fields.

Explanations for Departure from STEM Fields. Qualitative and quantitative research attributed African American women's underrepresentation in STEM fields to (1) individual factors, (2) school factors, (3) the home environment, (4) environmental factors, and (5) limited access to careers. First individual factors that account for fewer African American women engaging in STEM fields. Social psychological literature attributes African American's departure from STEM fields to an individual factor, sense of belonging or ill-fit within science communities. For instance in high school, Gilmartin et al. (2006) found that:

African American girls' lower levels of interest were explained by their tendency to disagree with statements like 'I think I could be a good scientist one day' and their lower likelihood of having many physical science and engineering-related hobbies (p. 194).

Similarly, in high school Black female teenagers felt unwelcomed due to their race rather than gender inside science classrooms (Hanson, 2006). This was contrary to their white female counterparts who reported fewer issues of fit within the science classroom in this research study. In college, some African American women faced racism, sexism, and isolation while pursuing scientific degrees and working in research labs as a part of their careers (Jordan, 2006; Sands, 2009).

Second, the school factor of academic preparation influenced African American women departing from the STEM pipeline. In the passage below Hanson and Johnson (2000) found that African American middle school girls are:

More likely to attend earth science and biology classes in the 8th grade and earth science and computer education classes in the 10th grade. They were however, less likely to be attending laboratory classes in the 8th grade and to report being in a science less when asked in their senior year (p. 282).

From this excerpt, in high school, Black girls must be encouraged to take additional math and science courses that meet the minimum requirement for college preparation (Bradley, 1997; Parrott et al., 2000). In college, some Black women's challenges in STEM fields might be due to their K-12 preparation. Some Black women are less prepared for college-level math, science, and engineering, because they took few higher level math and science classes (Malcom, 1993). Consider for example Wisdom who obtained Bachelor of Science degree in biomedical engineering at a PWI (McGee, 2009). Wisdom felt that her high school ill-prepared her to engage in the math curriculum at the undergraduate level. Other peers doubted her abilities and felt as though she only got into their institution because of affirmative action.

In graduate school, Black women's challenges in STEM fields inside the classroom, included: isolation *being the only one*, the curriculum, socializing and studying with peers, and interacting with faculty members (Justin-Johnson, 2004). Some Black women had bad advising experiences and limited mentors as well. Outside of the classroom, African American women's hardships included socializing with science peers outside of study groups. Even in academia, Euphemia Lofton Haynes reported that her contributions to the mathematical community remained invisible (Kenshaft, 2005). She claimed that it was "due to the systematic exclusion of African Americans, especially in the South, from meetings of the mathematical societies during her career" (Kenshaft, 2005, p. 97). These incidents led to some Black women (e.g. Evelyn Hammonds) to believe that they "were never meant to survive" (Sands, 2009, p. 31). Hence, discrimination and the science culture might make African American women feel like they do not belong in the field of science.

Some policy recommendations for researchers to address this problem are making them feel comfortable and welcomed in science classrooms (Ceglie, 2009; Hanson, 2006). Additional school factors that cause African American women to forsake STEM fields are limited support from teachers and peers. Consider for example, Jennie R. Patrick earned a Ph.D. from MIT in engineering in 1979 (Warren, 1998). As a teenager, she was discouraged from going to college by teachers and school counselors. However, she was determined to pursue her interest in science and technology, so she majored in chemical engineering at the University of California-Berkeley. Similar to earlier educational experiences, she faced adversity with the academic rigor of the chemical engineering curriculum along with racism in the doctoral program.

Third, home factors influenced the departure of African American women from STEM fields. Research shows that some African American women lack mentorship, role models, and family support (Jordan, 2006; Warren, 2005). As a result, some researchers recommend producing more role models and instructors to give African American girls and women encouragement to pursue the career aspirations of their choice (Bradley, 1997; Evans, 2007; Perna et al., 2009).

Fourth, the environment, namely the science culture at PWIs is an environmental factor influencing African American women's departure from STEM fields. For instance, some African American women took science classes in which they learned little about the contributions of Black scientists (Bradley, 1997). They also had few role models or teachers who looked like them based on race or gender (Bradley, 1997; Justin-Johnson, 2004). Hence, science textbooks should be inclusive of Black scientists' contributions to the field of science to encourage Black girls' pursuit of the study of science in school and careers as well (Bradley, 1997).

Finally, limited access to careers in STEM fields might explain why some African American women depart those fields. For instance, the second Black female mathematician, Dr. Granville was never discouraged from pursuing the major of her choice. Her parents and teachers instilled the value of education at an early age (Jordan, 2006). Her family supported her educational goals. She found her race and gender to be beneficial to obtaining teaching positions in mathematics with the exception of being denied to a job. She believes scientists can serve as role models and mentors to Black women pursuing degrees in science at the undergraduate level.

Explanations for Remaining in STEM Fields. To counter the above mentioned research on underrepresentation, a growing body of literature discusses the reasons why some African American women remain in STEM fields. These include (1) individual factors, (2) school factors, (3) the home environment, (4) environmental factors, and (5) early career interests in science.

First, individual factors of intellectual competence and academic confidence might explain why some African American girls remain in science. In one research study, Black females “are more likely than White females to disagree with the statements suggesting they aren’t interested in science or don’t do well in it” (Hanson & Johnson, 2000, p. 282). In fact, they are interested in science and math at early ages (Jordan, 2006). For instance, mathematician, Dr. Vivienne Malone Mayes was interested in math at an early age (Henrion, 1997). Another mathematician, Fern Hunt enjoyed math in high school. Hands-on experiences such as laboratory experiments sparked some African American girls’ interest in pursuing science oriented careers as well (Jordan, 1999). Determination and motivation accounted for some Black women’s persistence, retention, and graduation from science majors in college (Justin-Johnson, 2004).

Second, school factors like support from instructors might explain why some African American women stay in STEM fields. Consider the fact that historically, African American women scientists, mathematicians, and engineers had supportive teachers to encourage them to pursue STEM degrees and careers (Herion, 1997; Warren, 1998; Jordan, 1999, 2006). A former NASA Aerospace engineer, Christine Voncile Mann Darden enjoyed math “since junior year in high school” (Warren, 1998, p. 77). She received encouragement from teachers in her pursuit of science and engineering interests as well. Furthermore, in college, some African American women who built relationships with faculty members persisted in science majors (Justin-Johnson, 2004).

Third, the home environment positively influences Black women’s persistence in STEM fields. Evidence also confirms African American women utilized support systems (e.g., family, friends, and community members) as resources to continue engaging in science curriculum in primary and secondary schools, to persist, and obtain degrees in hard science majors in college (Edwards, 2002; Hanson & Johnson, 2000; Jordan, 2006; Justin-Johnson, 2004; Warren, 1998). For instance, with parental support, mathematician, Vivienne Malone-Mayes was motivated to engage in math for the love of it (Henrion, 1997). She also enjoyed math for social change purposes “to expand the opportunities available to future Black students” (Henrion, 1997, p. 209). Similarly, in graduate school support from family and friends provided some African American women with motivation to persist in science programs (Justin-Johnson, 2004).

Fourth, the science culture is an environmental factor that influenced African American women remaining in STEM fields. Consider for example the reflections of two Black women who revealed that some caring middle school, high school, and college math teachers accounted for their success in math (Moody, 2003). These teachers encouraged students and made sure they

understood the mathematical problems). Being able to make real-life applications of the math concepts and cooperative learning were important to help them fully understand the math course materials as well.

Equally as important, science identity formation are environmental factors that explain why some African American women remained in STEM fields. Research found that Black women who formed science identities overcame barriers (e.g., classroom performance, isolation), due to race and gender became successful in the college-level science curriculum (Ceglie, 2009). They were also more likely to persist and graduate with degrees in science as well. Black women in science were determined and motivated to succeed in the field of science as well. Hence, forming science identities resulted in some Black women overcoming academic, racial, and gender barriers. This in turn accounted for these Black women's persistence, retention, and graduation from college with degrees in science.

Finally, early science interests relating to careers might explain why some African American women continued in STEM fields. Research showed that in girlhood some African American women showed an interest in science at an early age in elementary school (Jordan, 2006). This might have accounted for some African American women pursuing science as a major in college and careers (Jordan, 2006). Engagement in science was thus tied to Black girls' interests in science related careers as well (Gilmartin et al., 2006). For instance, the first Black woman mechanical engineer (B.S. Howard University) and industrial engineer (M.S., Vanderbilt University), Yvonne Young Clark was always interested in science. Her parents supported her educational trajectory. While self-motivation and determination enabled her to pursue her educational goals at Howard University, her race and/or gender barred her from obtaining jobs at the Navy, and Ford Glass Plant. At Vanderbilt University, through networking, she gained entry

to an engineering position at the Ford Glass Plant where she became the first Black female engineer. From this section, it is clear that some African American women might be interested in science at as early age and pursue science degrees. However, racial and gender discrimination might hinder them obtaining entry into male-dominated fields. This might result in them being underrepresented in research positions (Jordan, 1999).

Summary of Research on African American Women in STEM Fields

In conclusion, quantitative research shows that African American women are underrepresented in STEM fields. Some explanations for African American women leaving STEM fields are individual factors (e.g., sense of belonging), school factors (e.g., academic preparation), home environment (e.g., limited role models, family support), environment (e.g., science culture) and accessibility to careers. Moreover, African American women remain in STEM fields due to individual factors (e.g., academic and intellectual competence), school factors (e.g., support from instructors), home environment (e.g., family support, community support), environment (e.g., science culture), and career aspirations.

Equally as important are gaps and holes in this strand of research. First, few researchers examined the role of individual, school, home, and environmental factors in impacting the continuance or departure of African American women from STEM fields throughout the educational pipeline. Second, limited research explored the connection of career aspirations to African American women to leave or stay in STEM fields using a K-16 approach. Third, previous research studies on the underrepresentation of African American women omitted an intersectional framework that includes an analysis of race, class, and gender issues and how these identities connect to their experiences in STEM fields. Fourth, there is a limited understanding of how African American women feel a sense of belonging in STEM communities across the

educational pipeline. As a result, future research should examine the role of identity formation in STEM communities for African American girls and women. Fifth, few research studies have looked at how teaching and pedagogy influences Black girls and women's engagement in STEM fields.

Furthermore, knowledge of the hidden curriculum in STEM fields across the educational pipeline might be advantageous for researchers to examine to better understand why some African American women remain or depart from STEM fields throughout the educational pipeline. The cultural capital that African American women might use to navigate through undergraduate STEM programs will contribute to the literature on persistence, retention, and graduation in college. Finally, there are few explanations for why some African American women commit to STEM majors while others do not.

Limitations of Existing Research: Rationale for the Current Study

As previously described minorities and women are underrepresented in STEM majors (see Bowen, Chingos, & McPherson, 2009; National Science Foundation, 2007, 2009). The majority of STEM research on minorities, women, women of color, and African American women lacks an intersectional focus centering on race, class, gender, and nation. So, there is a limited understanding in the differences between underrepresented students who persist or depart from STEM fields due to race, gender, and social class. Equally as important, individual factors, school factors, the home environment, environment, STEM culture, and career (e.g., access, aspirations) influences whether or not women or minorities stay or forsake STEM fields. However, few studies documented the experiences of underrepresented groups across the educational pipeline. Hence, the current study will fill these gaps by employing the theoretical framework of Black Feminist Thought along with concepts, cultural capital, science identity

formation and commitment to understand why some African American women persist in science majors and why others do not across the educational pipeline. The next section further elaborates on the theories and concepts guiding the study.

Theories and Concepts to Understand African American Women in Science Majors

This multiple case research study fills some gaps in the previous literature by merging the theory of Black Feminist Thought with concepts of cultural capital, science identity formation, and commitment to understand African American women's persistence in science majors at a PWI. Following is a description of the theory and concepts employed in the study.

Black Feminist Thought

Black Feminist Thought sheds light into Black women's interlocking forms of oppression (e.g., racism, sexism, and classism) in their everyday lived experiences (Collins, 2000; Crenshaw, 1995; hooks, 2000; Smith, 2000; Springer, 2005). It also privileges Black women's knowledge through every day lived experiences with multiple identities (e.g., race, class, gender, sexuality, nation), which might account for their experiences of discrimination (Collins, 2000; Feagin & Yanick, 1998). These experiences include: *being the only one* in the work place, sexual harassment in the workplace, control of their bodies through rape, domestic violence, hairstyles, and reproductive rights.

Being the only one showed up as a concern of Black women in leading positions in corporate America (Reid-Merritt, 1996). The Sears Roebuck president, Paula Banks said "Yes, I am 'a first black,' and certainly a 'first female.' I was the first Black woman to be the Equal Opportunity director for the company in a twelve-state area" (Reid-Merritt, 1996, p. 94). Other Black women like Emma *played the game* in which they collaborated with powerful executive male peers instead of just serving as leading ladies in isolated environments.

Despite being an educated, leading lady in Corporate America, a Black woman, Anita Hill encountered sexism in the workplace. In the Hill-Thomas hearing, the defendant Clarence Thomas alleged that he was the victim, due to his race as African American in the sexual harassment case (Davis & Wildman, 1999). However, Anita Hill's raced and gendered experiences of sexual harassment were invisible to the judiciary process within the court system (Smith, 2000). Thus, she lost the case.

Similarly, in the Federal Court case, *Rogers v. American Airlines*, Renee Rogers, an African American woman claimed that she was discriminated against in the workplace due to her race and gender, because the airport wanted to fire her for wearing a braided hair style at the (Rogers v. American Airlines, 1981). The court ruled that American Airlines worker, Rogers remove the braided hairstyle. Likewise, an African American woman, Cheryl Tatum was fired for wearing braids as a restaurant cashier in the Hyatt (Caldwell, 1999). To add to that, the legal system attempted to prosecute Black mothers who were crack addicts who became pregnant (Roberts, 1999). In 1989, the 23-year old Jennifer Clarise Johnson the "Florida law enforcement officials charged Johnson with two counts of delivering a controlled substance to a minor after her two children tested positive for cocaine at birth" (p. 127).

Furthermore, some Black females dealt with violence inside and outside of their homes. Consider for example that beginning in slavery, some female slaves endured sexual violence (e.g. rape) in which their bodies were controlled by their slavemasters (Guy-Sheftall, 2005). Since then Black girls and women continue to be raped (Collins, 2000; Ladner, 1995; Shange, 1980), and battered by partners (Collins, 2000). Black women's bodies are controlled through the government in the case of welfare queens as well (Collins, 2000). The 1973 *Roe v. Wade* decision gave all women the right to choose whether or not to keep their babies. Thus, through

the literature motherhood is racialized, classed, and gendered and so are mothers' treatments by medical professionals (Ikemoto, 1999).

As shown above, the majority of literature on Black Feminist Thought is centered in the legal arena in the workplace or health related issues (e.g., controlling their bodies). A few scholars observe that education can liberate women (see hooks, 2000) or restricts them in the academy due to being one of the few (Harris, 1997). Even fewer scholars connected the double burdens of race and gender in Black women's everyday lived experiences to health issues like stress, depression, or suicide (Jones & Shorter-Gooden, 2003; Shange, 1980). Few studies have employed Black Feminist Thought to understand the everyday lived experiences of African American women in hard science majors in higher education (see Justin-Johnson, 2004). Even fewer studies examined Black women's health related issues like stress, depression, and suicidal thoughts while navigating through hard science majors. As a consequence, Black Feminist Thought continues to lack a connection to not only higher education, but the persistence of African American women in hard science majors (Justin-Johnson, 2004).

To add that, Black Feminist Thought literature omits connections to education and resources that is, cultural capital that Black women use to overcome obstacles in schools. Traditional cultural capital, therefore, serves as the hidden curriculum practiced inside the traditional middle-class culture (Feinberg & Solitis, 2009; Bourdieu, 1984). To add to that, nontraditional cultural capital helps people navigate the non-dominant cultures that might be ethnic (Carter, 2003; Yosso, 2006). In this case, people are looking for ways to measure authenticity through identity. Consider for example a study on how undergraduate Black women in college negotiated their identities, culture, and home life on and off campus at PWIs (Banks, 2009). In this study, Black women utilized cultural capital instead of Black Feminist Thought to

understand their experiences in college. Hence the application of Black Feminist Thought might be helpful for a richer understanding of African American women's experiences in higher education, especially in STEM fields. The next section further describes the concept of cultural capital.

Cultural Capital

By connecting Black Feminist Thought to cultural capital using a strengths-based approach researchers might be able to better understand African American women students' access to hidden curriculum in K-16 settings, especially science communities in higher education. For example in the field of science, some Black women debunked stereotypes of their intellectual abilities and show how they engaged in the same science and math curriculum (Jordan, 2006; Warren, 1998) as their peers and form science identities (Carlone & Johnson, 2007). By acknowledging Black women's access to cultural capital, one can better understand how they participate in science communities inside and outside of the classroom. This is in opposition to the literature on the traditional form of cultural capital. In fact the traditional form of cultural capital serves as the hidden curriculum for practices to socialize kids in the middle-class culture inside and outside of classrooms culture (Bourdieu, 1984; Feinberg & Solitis, 2009). The traditional perspective of cultural capital focuses on the connection of cultural tastes to families with a higher social class (Bourdieu, 1984). Access to cultural capital then, provides people of middle and higher social classes with a legitimate taste for forms of culture, including artwork, music, museums, and cinema. The differences in cultural tastes might reflect the dominant culture's tastes over other people's cultural values.

However, the problem with the early conceptualization of cultural capital by Pierre Bourdieu was a disconnection of cultural capital from race, gender, or academic success (Lareau,

2003; Lareau, & Weininger, 2003). By connecting cultural capital to gender, Dumais (2002) observes that mothers transmitted cultural capital to children that may be used inside or outside of classrooms. Additionally, girls showcased their cultural knowledge by scoring high marks in classes. They also participated in cultural activities, including: dance lessons, art lessons, and music lessons, reading at the library, concerts, and museum visits. On the other hand, some boys might not fully display their cultural knowledge by participating in cultural activities outside of the classroom.

Scholarship in the sociology of education has contributed to the racialized discussions of cultural capital in primary and secondary settings. For example, Lareau (2003) observed that white and Black middle-class parents made efforts to cultivate their kids' talents by engaging them in activities in which they practiced those talents. On the other hand, kids from working-class and poor families participated in natural growth through informal play activities, in which they learned to be more independent (Lareau, 2003; Lareau, & Weininger, 2003). This research pointed to the relatively few research studies connecting cultural capital to racialized groups.

Outside of sociological research, research centered on secondary and postsecondary institutions found that students of color acquire cultural capital by persisting, developing social identities, growing interpersonally and intrapersonally, and carrying the value of civic responsibility (Aragon & Kose, 2007). Critical race scholars (Mickelson, 2003; Yosso, 2006) also added to the debates and discussions of the connection of race in cultural capital by acknowledging that students of color aspire to continue pursuing their dreams despite obstacles, which is the essence of aspirational capital, a non-traditional form of cultural capital. By using a critical race theory perspective, Yosso (2006) criticized Bourdieu's model of cultural capital for the absence of race. She found that communities of color acquire cultural wealth through specific

types of capital, including: “aspirational, navigational, social, linguistic, familial, and resistant capital” (Yosso, 2006, p. 176).

Equally as important is the cultural capital that African American women use to navigate through science communities at a PWI. This might include developing science identities, successfully passing science and math classes, or committing to hard science majors. It will also be important to better understand how the hidden hard science culture might influence African American women’s departure from hard science majors, due to an ill-fit within the science community. Consider for example that the science equity research reported disconnections from students’ culture and the science curriculum and science pedagogy (Lee & Luykx, 2006; Southerland, Smith, Sowell, & Kittleson, 2007). Often times the science curriculum centers on a Western model that devalues the exploration of non-Western scientists (Lee & Luykx, 2006).

Lee and Luykx (2006) point out that:

When students do not share the ‘culture of power’ of the dominant society (e.g., Western science), teachers need to make that culture’s rules and norms explicit and visible so that students can learn to cross cultural borders between their home environment and the school environment (p. 90).

These hidden rules and norms can be described as a form of hidden curriculum as noted in the cultural capital research (see Feinberg & Solitis, 2009). By providing access to information (e.g., cultural capital), students can become knowledgeable about the rules and norms “for classroom behavior and academic achievement” (Lee & Luykx, 2006, p. 76). Additionally, by having access to knowledge of the culture of science, students might have the opportunity to learn and perform well academically if they obtain the same exposure to the science culture as their peers outside of academic settings. Furthermore, students who learn the values, rules, and regulations through explicit instruction via socialization to communicate using scientific terminology, understand scientific texts, and engage in projects in research labs (Southerland et

al., 2007). This in turn might make it easier for students to navigate through the science culture and have more opportunities to learn in science communities.

However, what continues to be lacking in cultural capital research is a connection of the hidden curriculum to African American women's continuance or departure from hard science majors due to exposure to science related activities throughout the educational pipeline. Hence the use of the cultural capital framework is appropriate for the current study to examine their access to traditional and non-traditional cultural capital. It will be important to understand their availability to resources (e.g., teachers, peers, and family members) to remain in these fields as well. Following this section is a discussion of science identity formation, which involves learning about the hidden science curriculum.

Science Identity Formation

Learning the hidden curriculum (e.g., cultural capital) in science communities is connected to a person's science identity formation. As conceptualized by Carlone and Johnson (2007), science identity formation is based on three themes, competence, performance, and recognition. The first theme competence centers on a person's knowledge of science. It is often tested through academic performance. This is commonly referred to as known as intellectual competence in the literature. At the collegiate level, intellectual competence centers on "using the mind's skills to comprehend, reflect, analyze, synthesize and interpret" (Chickering & Reisser, 1993, p. 53). It also requires for students to engage in the processes of "mastering content, acquiring aesthetic appreciation and cultural aspects, and perhaps most important, developing the ability to reason, solve problems, weigh evidence, think originally, and engage in active learning" (pp. 53-54). Chickering & Reisser (1993) also point out that "a sense of

competence stems from the confidence that one can cope with what comes and achieve goals successfully” (p. 53).

The second theme in science identity formation is performance. In this phase of science identity formation, a person performance by engaging in projects utilizing scientific methods and converses about scientific methods (Carlone & Johnson, 2007). The third theme of science identity formation is recognition. Carlone and Johnson (2007) point out that a person’s recognition as a part of the science community and scientists acknowledging a person as a part science community are important to making a person feel as though they belong inside the science community.

Research also confirms that women of color’s recognition within the science identity formation framework stems from engagement in the research programs, internships, and volunteer opportunities in the sciences (Ceglie, 2009). However, within science classrooms, some African American girls feel marginalized due to their raced, classed, and gendered identities (Hanson, 2004; Warren, 1998). This marginalization might result in their lack of science identities (Jordan, 2006). The hidden science culture might affect their academic performance in science classes (Southerland et al., 2007). While the science identity formation research has centered on race and gender and more specifically women of color’s persistence in the hard sciences (Carlone & Johnson, 2007; Ceglie, 2009), it omits a focus on the explicit experiences of African American women in hard science majors. So, we do not know the differences in science identity formation based on the multiple identities of African American women.

Research is also limited in connecting interpersonal competence to students’ science identity formation and their persistence in hard science majors. Interpersonal competence can be

described as a person's ability to communicate and work well together with others (Chickering & Reisser, 1993; Pascarella & Terenzini, 2005). Interpersonal competence also "includes an array of discrete skills, like listening, asking questions, self-disclosing, giving feedback, and participating in dialogues that bring insight and enjoyment" (Chickering & Reisser, 1993, p. 72). This quote points to the fact that interpersonal competence requires students to communicate effectively with others in groups, whether it is in front of the classroom, with the instructor, or peers during group work. While we know that some college students develop interpersonal and intrapersonal competence as they form identities in college (Chickering & Reisser, 1993), there is limited research on science identity formation for African American women to commit to or forsake hard science majors at PWIs. The next section will discuss the concept of commitment and how it might tie to the persistence of African American women in hard science majors.

Commitment

Commitment might explain why some African American women commit to hard science majors or transfer to social science or health science majors. The concept of commitment as noted by Locke, Latham, and Erez (1988) "refers to one's attachment to or determination to reach a goal, regardless of the goal's origin" (p. 24). Becker (1960) observes that "sociologists typically make use of the concept of commitment when they are trying to account for the fact that people engage in consistent lines of activity" (p. 33). This commitment has to be clear to explain people's behavior and rationale for why they commit to one thing as opposed to another. The notion of commitment thus involves a deliberate decision to participate in something. Some people who commit engage in a side bet. By doing so "the committed person has acted in such a way as to involve other interests of his, originally extraneous to the action he is engaged in, directly in that action" (Becker, 1960, p. 35).

Others may commit to something without even knowing they have fully committed to it. These commitments come with values, benefits and costs. Others have used the term commitment when describing how a person commits to a career (Ritzer & Trice, 1969). Ritzer and Trice (1969) found that “in order to make his work life meaningful, one must commit himself to either his occupation or his organization” (p. 478). This quote points to the fact that being committed to one’s occupation may enable them to stay longer at the position or organization. People who are less committed to their jobs are more likely to depart. To add to that, in the field of higher education, women who engage in learning a subject like science have personal connection to the subject matter, often referred to as a science identity (Brickhouse et al., 2000; Thompson & Windschitl, 2005). Some women committed to engaging in the science curriculum and thus are more likely to persist in science in college (Brickhouse et al., 2000; Thompson & Windschitl, 2005; Worthley, 1992) or careers as well (Williams & Emerson, 2008).

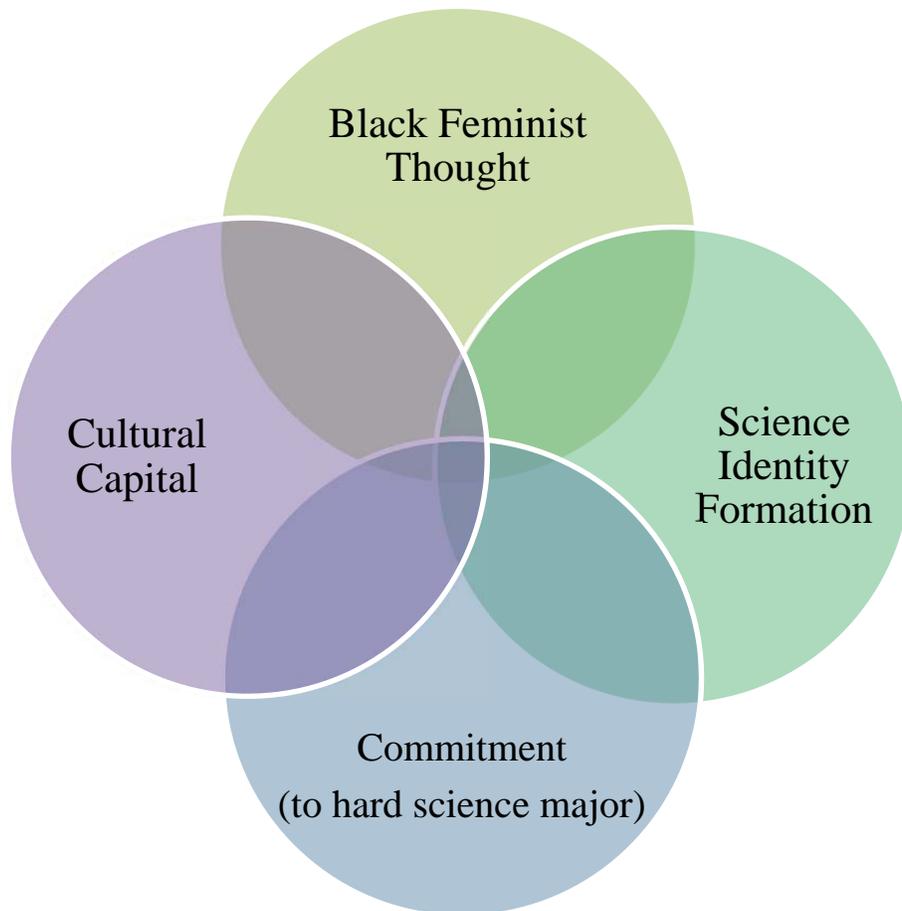
Research on commitment to hard science majors is limited in examining the role of race, gender, and social class in how people persist in science majors (see Tyson et al., 2010). Therefore, the literature lacks an understanding of how commitment is tied to the African American women’s persistence in hard science majors.

Conceptualizing African American Women’s Persistence in Hard Science Majors

This section provides visual models of African American women’s persistence in hard science majors. The first model in Figure 1 entitled “Framework for African American Women’s Persistence in Hard Science” shows the merger of the frameworks Black Feminist Thought, cultural capital, science identity formation, and commitment. Following that is an explanation of the model. The next model in Figure 2, “A K-16 Approach for Understanding the of Persistence of African American Women Pursuing Hard Science Majors” provides a richer

understanding of African American women's decisions to stay or leave hard science majors across the educational pipeline in K-16 settings. The model is described in the section that follows.

Figure 1. Framework for African American Women’s Persistence in Hard Science Majors



The conceptual model above in Figure 1 shows the intersections of each of the theories and/or concepts to explain why some African American women persist in hard science majors. As stated in the literature (see Collins, 2000) Black Feminist Thought focuses on Black women's everyday lived experiences with oppression due to their multiple identities. Yet few studies applied this framework to education (see Justin-Johnson, 2004). In this study, Black Feminist Thought examines Black women's persistence in hard science majors by understanding their everyday lived experiences, including adversity in the hard science majors via the curriculum, interactions, with peers and/or instructors throughout the K-16 pipeline. To further connect Black Feminist Thought to education, it is important to merge this framework with cultural capital to understand the hidden science curriculum (see Feinberg & Solitis, 2009) that African American women must learn before and during college to navigate through hard science majors in postsecondary settings at the undergraduate level.

Tied to the hidden science curriculum is science identity formation, that is competence, performance, and recognition (see Carlone & Johnson, 2007). It is important to understand how African American women form science identities and if the science identity formation in turn influences their persistence and commitment to hard science majors. In sum, the merger of Black Feminist Thought with cultural capital, science identity formation, and commitment will explain why some African American women persist and commit to hard science majors. It will help us understand how African American women's adversity in hard science majors is due to their multiple identities, access to resources, cultural capital, and science identity formation.

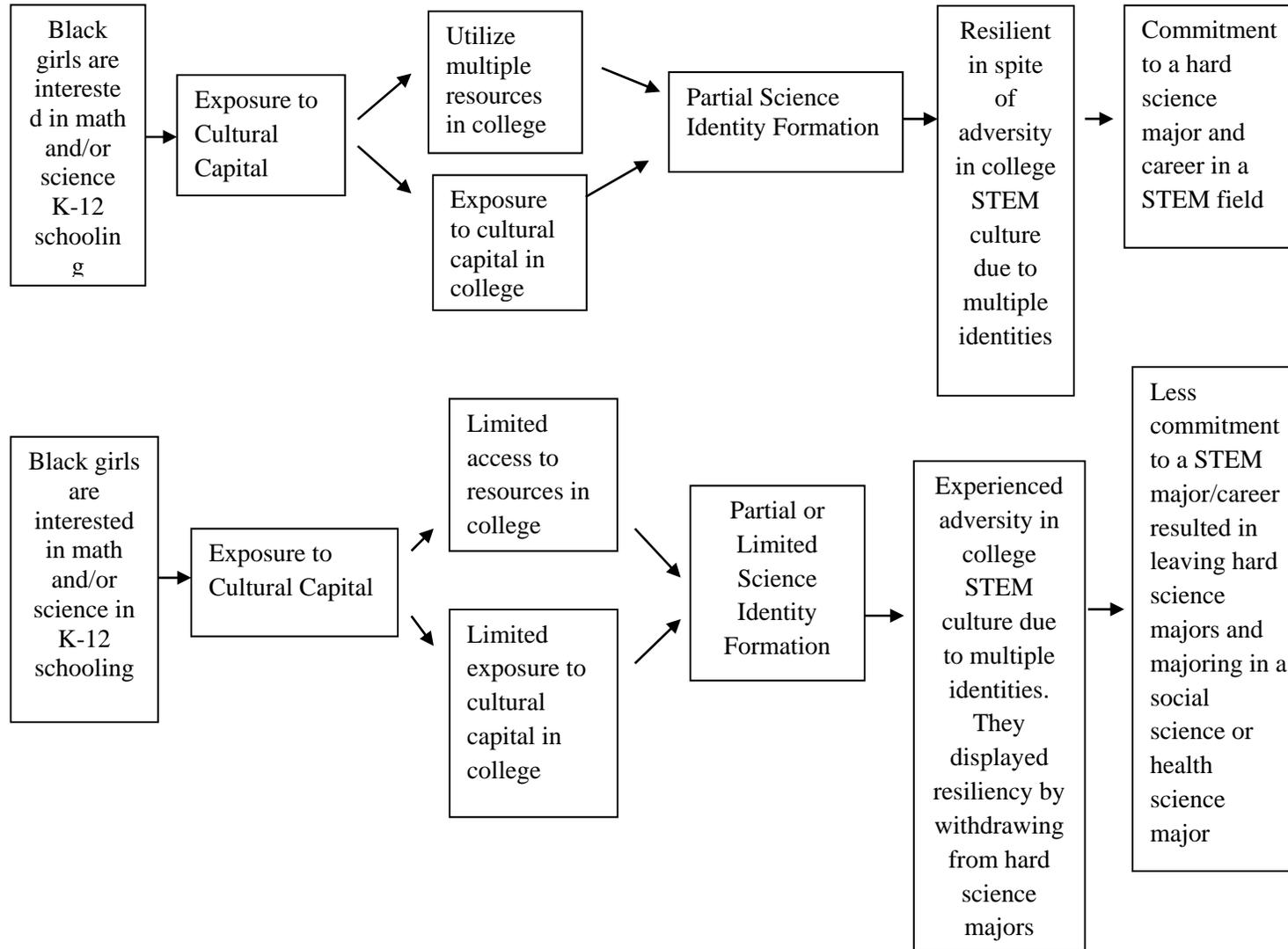
A K-16 Approach for Understanding the of Persistence of African American Women Pursuing Hard Science Majors

Below in Figure 2 the researcher developed a K-16 pipeline approach to account for the different pathways for African American women students who commit or forego the hard science majors. Using this approach, the model begins with African American women's engagement in math and science in K-12 schools. It continues to document their persistence in these fields in college. In the first model, Black girls who are exposed to cultural capital in K-12 school settings are more likely to utilize resources (e.g., support from peers, family, instructors, and mentors) in college. They are also exposed to science related activities (e.g., research labs, science conferences) in college. Through this exposure to science related activities and resources, they may be more likely to form partial science identities and thus better adjust to the science culture. Equally as important, by overcoming obstacles, personal, school, home, they persisted in hard science majors and committed earning degrees in hard science majors and careers in STEM fields.

The second model (see Figure 2) reflects Black girls who have exposure to cultural capital in K-12 school settings. They may also use resources in college. However, they have fewer resources in hard science majors in college. This in turn may explain why they feel like an ill-fit or ill-match within the hard science culture at the university and form a partial or limited science identity. So, when some African American women experienced adversity in the science culture, they became less committed to pursuing a degree in a hard science major and/or a career in a STEM field. So, they were more likely to exhibit resiliency by departing the hard science majors and moving into the health science or social science majors where they were more likely to obtain a bachelor's degree, due to interest in the major.

Figure 2:

A K-16 Approach for Understanding African American Women's Persistence in Hard Science Majors



Concluding Summary

Research confirms that minorities and women are underrepresented in STEM fields. In addition women and minorities' continuance or departure from STEM fields are due to individual factors, school factors, home environment, environment, STEM culture, and career aspirations. However, this research omits a discussion of differences between groups using an intersectional perspective to account for different experiences based on race, class, and gender. To fill this gap, a handful of researchers conducted studies on women of color and African American women. Yet these studies only focused on primary, secondary, or postsecondary settings instead of using a K-16 pipeline approach. Hence, the current study focuses on the persistence of African American women students in hard science majors across the educational pipeline in K-16 settings.

Equally as important, this study is relevant to the field of higher education because it will fill the previous gaps in the literature, including qualitative methods, studying an rare population, African American women in the field of science at a PWI. It also adds to the theories and concepts of intersectionality, science identity formation, cultural capital, and commitment by examining the persistence of African American women in hard science majors at a PWI. The next chapter further discusses the methods used to understand the persistence of African American women in hard science majors at Town University.

CHAPTER 3

RESEARCH METHODS

Qualitative research is a method that centers on discovering the meanings, processes, and activities of individuals or a select group of people (Creswell, 2003; Krathwohl, 2004). Its purpose is not to generalize results to a larger population but to enable a better understanding of an issue or phenomenon as experienced by humans. One benefit of using qualitative methods is that the researcher can study an under-researched issue by asking open-ended questions. Second, the researcher “must emphasize discovery rather than validation or confirmation” (Creswell, 2003, p. 230). Furthermore, through this specific method we know as the single case study design, qualitative research allows for an in-depth study of an individual, situation or problem within a specific case that is bounded by a specific context (Stake, 1995; Krathwohl, 2004). In contrast, the multiple case study design differs from the single case study design in that it tries to replicate the method with multiple cases to determine if there are similar results or patterns across multiple cases (Yin, 2009). The following section proposes some limitations of past qualitative research on African American women in science, technology, engineering, and math (STEM) fields that warrant the current research study.

Although African American women are one of the fastest growing populations in higher education, they continue to be underrepresented in hard science majors (National Academy of Sciences, National Academy of Engineering & Institute of Medicine of the National Academies, 2007; National Research Council of the National Academies, 2006). To add to that, what remains a problem in the literature is that few researchers utilized qualitative methods to examine the experiences of African American women in hard science majors (see Hanson, 2006; Hanson & Johnson, 2000; Jordan, 2006; Justin-Johnson, 2004; Warren, 1998). This gap in the literature warrants the current exploratory multiple case research study. The main research

question was: Why do some African American women at a predominantly white institution persist in hard science majors while others depart from hard science majors?

This chapter discusses the methods that were used to conduct the study. It begins by explaining the research design and follows with the research objectives. It then describes the purpose of the study, the sampling and recruitment strategies, data collection, rationale for participant selection and research site, and the data management strategies. This chapter ends with an examination of limitations and delimitations of the study, and the researcher's biases.

Case Study Research Design

This exploratory study began with the intention of recruiting 16 multiple cases. In this study, the *multiple cases* are the African American women who persisted in hard science majors or transitioned from hard science majors into social science or health science majors. These African American women were purposefully chosen to participate in the study based on the criteria outlined in the sampling and recruitment strategies section. Eight of the African American women were hard science majors. Seven of the African American women transferred out of hard science majors. Of this latter group, three transferred into social science majors and four switched into health science majors. However, one woman was in the process of moving from health science to chemistry. At the time of the study, she had not changed her major to chemistry. So, she was classified as a health science major.

The multiple case study methodological approach was appropriate to compare and contrast African American women's experiences navigating through the science culture with multiple identities, science identity formation, availability of resources, access to cultural capital, and commitment to hard science majors at Town University (pseudonym) as well. Often times, multiple case study researchers conduct the same experiment using purposefully chosen

populations and locations to determine if similar or different results are produced in the same context (Yin, 2003), which might be a school or hospital (Miles & Huberman, 1994). Therefore, the multiple case study methodology is appropriate when researchers want to compare and contrast findings of experiments using replication (Yin, 2009). When multiple case studies are conducted the data collection procedures include: observations, interviews, and/or document review, which is used to develop a case record and to write a case study narrative. Equally as important are interviews to obtain stories constructed and experienced by the participants (Seidman, 1998). In summary the multiple case study approach was appropriate for the current study, because it sought to better understand the differences between the experiences of African American women who remained or departed from hard science majors in the context of Town University. What follows is a discussion of the research objectives for this study.

Research Objectives

This exploratory qualitative research study intended to examine the persistence of undergraduate African American women in hard science majors at Town University, a PWI in the Midwest. It utilized the frameworks of Black Feminist Thought, cultural capital, science identity formation, and commitment. Some qualitative researchers have explored the role of science identity formation (e.g., competence, recognition, and performance) in the persistence of women of color in science in college (see Marlone & Barabino, 2008; Carlone & Johnson, 2007). However, few qualitative researchers explored the role of cultural capital, science identity formation, Black Feminist Thought, and commitment of undergraduate African American women to hard science majors. Therefore, the main question that guides this research study was: Why do some African American women persist at a predominantly white institution in hard science majors while others depart from hard science majors? The subsidiary questions were:

- (1) Does forming a science identity influence the persistence of undergraduate African American women students in science majors?
- (2) Does the availability of resources impact the persistence of African American women in science majors?
- (3) Does cultural capital affect the persistence of African American women in science majors?
- (4) Do African American women who persist in science majors face challenges based on multiple identities (e.g. race, class, gender, and ethnicity)?
- (5) What types of strategies do African American women use to persist in science majors?

The next section further adds to the aforesaid research questions by discussing the rationale for the study.

Purpose of the Study

This exploratory multiple case research study examined if there were differences in undergraduate African American women's access to resources and cultural capital, science identity formation, experiences in the science culture due to multiple identities, and commitment to science majors. The study began by exploring the women's neighborhood context and early schooling experiences from elementary school up to high school. It also examined their experiences in math and science classes at a PWI, taking into consideration the structure of teaching and learning. It was also important to see if there were differences between African American women's teaching, learning, and interactions with peers and instructors in K-12 settings and college. Hence, narratives of African American women who remained or departed from hard science majors might help colleges think better about approaches to facilitate the

persistence, retention, and graduation of hard science majors. The following section provides a discussion of the methods utilized to recruit participants for the study.

Sampling and Recruitment Strategies

The main sampling strategy in the study is purposive sampling. Creswell (2003) defined purposive sampling as a method that researchers use to “identify the purposefully selected sites or individuals for the proposed study” (p. 185). This sampling strategy illustrates that “sampling choices are made with the intent of developing understanding and an explanation of behavior over time” (Krathwohl, 2004, p. 260). It is also a sampling strategy to “select individuals or behaviors that will better inform the researcher regarding the current focus of an investigation” (Krathwohl, 2004, p. 172).

Consistent with the above research, a purposive sampling method was utilized to recruit 16 participants for this study. The recruitment of the participants took place via email. The study began with administrators in the Success Retention Program (pseudonym), the Sankofa Home (pseudonym), and Town University Leaders Program (pseudonym) forwarding a recruitment email to request students’ participation on the study. The students voluntarily elected to participate in the study. The actual participants were contacted via email and/or phone to schedule a time to review and sign the informed consent form, and participate in the first interview session.

Additionally, the criterion for participation in the study were (1) women who self-identified as African American or Black with upperclassman status based on credit hours. (2) They were also in hard science majors, such as Biology, Engineering, Mathematics, or Business; or they transferred out of the hard science major into social science majors (e.g., Sociology) or

health science majors at the Town University. (3) In addition, they were between the ages of 19 and 23. The recruitment phases of the participant selection are described below.

In phase one of recruitment, from March to April 2011, ten students agreed to participate in the study. However, three students who initially agreed to participate never turned in the consent forms. One student consented by phone, but she never signed an actual consent form, so she was removed from the study. Similarly, in phase two of the recruitment stage from May 2011 to August 2011, four African American women agreed to participate in the study. However, only one provided formal consent and participated in the study. In the third phase of the recruitment phase from September to October 2011 the researcher encountered barriers recruiting participants utilizing former gatekeepers. However, the researcher successfully encouraged one participant from phase two of the data collection to remain a part of the study, and that participant completed the interview phase of the study in November 2011. To generate additional participants, the researcher attempted to utilize participant referrals, but that yielded zero participants. Additional steps used to identify potential research participants were (1) peer contacts and (2) minority student organizations. Through these recruitment strategies, the researcher obtained nine participants. Of those nine, five fit the criteria and successfully completed the study. These additional steps produced no biases due to the women voluntarily electing to participate in the study. Equally as important in October 2011, one of the aforesaid administrators sent out an email that resulted in the recruitment of two additional participants. Hence, the researcher successfully identified and interviewed 16 participants in a total of 90 sessions (79 interviews and 11 follow up sessions).

Data Collection

The data for this study was collected from March 2011 to December 2011. The college-aged, African American women were provided with written consent forms prior to the interview. The participants signed the consent form and kept a copy for themselves. Subsequently, the interview sessions were scheduled at a time and place convenient for the participants. Participation in this study was fully voluntary. If a participant chose not to participate in any of the interviews, then their choices were fully respected.

Data collection consisted of the several procedures. First, a demographic information sheet to collect background information on the participant. Participants' social status was based on the Barratt Simplified Measure of Social Status (Barratt, 2006). This scale uses the educational and occupational attainment of parents to measure social status. A limitation of this measure is that there might be limited validity in measuring social class. As stated later in chapter 4, some African American women from middle class and working class families persisted or departed from hard science majors. Mother's education accounted for African American women's persistence in hard science majors as well. This finding is consistent with previous research studies. Scholars found that education was the best measure of social economic status (Featherman & Hauser, 1978; Hauser & Warren, 1997).

Second, an unstructured¹² face-to-face 8 to 30 minute interview to build rapport with the participant. Third, two structured¹³ interviews asked open-ended questions about the participants' experiences in primary and secondary schooling. The interview took one to three sessions and ranged from fifty minutes to two hours. This session was followed by a brief

¹² Unstructured exploratory interviews allow researchers to "adapt the questions to the immediate situation so as to increase rapport" (Krathwohl, 2004, p. 288).

¹³ Structured interviews are those in which the researcher develops the questions and order of questions before the interview is conducted. Semi-structured interviews have open-ended questions and the researchers decides the "questions and order of presentation" (Krathwohl, 2004, p. 287).

written reflection in the form of a personal document. Taylor and Bogdan (1998) define personal documents as “individuals’ written first-person accounts of their whole lives or parts of their lives, or their reflections on a specific event or topic” (p. 124).

There were also two separate in-depth¹⁴ interviews that lasted from an hour to three hours. The purpose of these interviews were to gain a better understanding of the participants’ experiences inside and outside of college classrooms, and the resources that they utilized to persist or depart from hard science majors. Additionally, the questions centered on science identity formation were informed by previous research (e.g., Carlone & Johnson, 2007; Ceglie, 2009) that has measured science identity formation based on performance, recognition, and competence.¹⁵ Equally as important was that the participants completed the brief reflections after the interview to further discuss issues that came up within the interview or any issue that may have been missed. With the permission of the participant, the researcher collected the written reflection. Finally, each interview was recorded with the permission of the participants using a digital recorder.

Rationale for Participant Selection

This section describes the reasons for choosing the participants for the study. First, saturation was a rationale for acquiring 16 participants. By having 16 participants, the researcher found patterns within and between participants who remained or departed from hard science majors. Saturation is defined as “when new observations cease to add much to previous ones” (Krathwohl, 2004, p. 260). Second, African American women were targeted for the study because they were underrepresented in graduating from PWIs with degrees in hard science

¹⁴ Researchers who conduct in-depth interviews focus on “learning how people construct their realities how they view, define, and experience the world” (Taylor & Bogdan, 1998, p. 101).

¹⁵ See the literature review for an in-depth explanation of the science identity framework used by Carlone & Johnson in 2007 and Ceglie in 2009.

majors (see Bowen, Chingos, McPherson, 2009; National Science Foundation, 2007, 2009).

Third, there was limited research on the persistence of undergraduate African American women in hard science majors (Carlone & Johnson, 2007; Giscombe, 2007; Hanson, 2006; Jordan, 2006; Justin-Jordan, 2004; Parrott et al., 2000; Perna et al., 2009; Warren, 1998). Therefore, targeting the specific population of African American women was appropriate to gain a better understanding of why some African American women persisted in hard science majors while others departed from these majors.

Fourth, the rationale for recruiting upperclassmen was two-fold. Upperclassmen took introductory and upper-level coursework, so they were knowledgeable about the differences in that curriculum and the expectations of college. It was also important to look at the differences between two populations, those who remained or departed from hard science majors across the educational pipeline. In this study, the researcher had the opportunity to compare and contrast the math and science classroom experiences of African American women who persisted or departed from hard science majors across the educational pipeline. Of particular concern was these women's access to upper level, advanced placement, or honors math and science classes in high school and subsequently their performance in introductory and upper level math, science, and/or engineering classes at Town University. Fifth, the researcher compared and contrasted the within differences among women who stayed in hard science majors. Finally, participants were selected due to their age. The traditional college population is between the ages of 18 and 24, so the participants who classified as juniors or seniors ranged in age from 19 to 23. Thus, African American women who fit this description were selected for the study. What follows is a discussion of the institutional context of Town University.

Rationale for the Research Site

This section describes the rationale for the selection of the research site, Town University. It begins with the demographics of the institution's student population, followed by the background of the geographic location of Maytown (pseudonym). Then it discusses the average educational and occupational attainment of people in Maytown.

First, Town University was chosen because of the undergraduate student population. Consider for example that Town University is a research intensive institution that serves over 40,000 students (U.S. Department of Education & National Center for Education Statistics, 2010). Over 10,000 of the population are graduate students, while over 30,000 students are classified as undergraduates. It offers programs leading to bachelors' degrees, masters' degrees, doctorates, medical degrees, and law degrees. There are slightly more men (over 55%) enrolled at the institution than women (about 45%) as well. The majority of students are white (about 60%), about 28% are minority students, about 9% are immigrants, and about 3% are students of an unknown racial minority.

The demographic data suggests that Town University is a PWI with a small pool of minority students enrolled at the undergraduate and graduate level. In addition, fewer minority students and women are enrolled in science majors at the university at the undergraduate and graduate level than their white male and international counterparts (U.S. Department of Education & National Center for Education Statistics, 2010). Moreover, the data shows that the attrition of women and minority students in science curriculum occurs more frequently during the freshman and sophomore years than the junior and senior years. This might be attributed to women and minority students' persistence by way of commitment or forgoing hard science

majors during the latter years for those who remain in the major, while those who depart the field of science may have been *cooled out*¹⁶ by withdrawing, due to the science culture.

Second, Town University was chosen because it was housed in a predominantly white industrial town, Maytown, in which African American women would be classified in the minority. So this setting might offer additional insight into the challenges that African American women face at PWIs in small towns. Consider, for example, that Maytown's population is fewer than 85,000 people and it is considered a majority white population with more than 50,000 white residents (U.S. Census Bureau, 2009). There are, however, enclaves with people of color, including African Americans (fewer than 12,000), Native Americans (fewer than 50), and Latino/as (fewer than 4,000). The international population has increased throughout the years as well due to a growing number of international students and families living in the area.

Regarding the population's attributes, Maytown has a small educational system within the community. Maytown also has fewer than five local public high schools and one private high school. There are fewer than five middle schools, but over 15 elementary schools as well. Despite the small educational system, over 90% of the population aged 25 and older have obtained at least a high school diploma. Less than 50% of the same population, however, holds a bachelor's degree or graduate school degree.

Many of Maytown's community members have secured employment. According to the U.S. Census Bureau (2009), over 60% of people aged 16 or older in the Maytown community are employed. Additionally, the U.S. Census (2008) reports that Maytown has the following

¹⁶ Cooling out is a term used by Clark (1975) to describe the disengagement of low-income students in community colleges, due to their low performance on pre-entrance exams. In fact, their exam performance placed them into remedial classes. Some students who were unable to raise their exam scores forewent careers and/or degrees even at the community college level. The researcher applied the term "cooling-out" to African American women who were discouraged from engaging in hard science majors due to the rigor of the math and/or science curriculum at Town University.

industries: wholesale trade, retail trade, transportation, finance and insurance, real estate and rental leasing, information, manufacturing, technical services, food services, educational services, health care, social services, arts, entertainment, and recreation. Maytown's main employer is Town University. It employs workers as faculty members, administrators, staff, student workers, and extra help who might be seasonal or part-time workers. Residents unaffiliated with the University work at local businesses within the community. These local businesses consist of chain fast food places, dine-in restaurants, grocery stores, retail stores, car dealerships, hotels, motels, dental offices, two hospitals, a factory, hair and barber shops.

Data Management and Analysis

This section describes the data management and analysis methods in the study. First, the data was managed through an audit trail, a record of the data collection procedures (Krathwohl, 2004). The purpose of an audit trail is to demonstrate how the data became "reduced, analyzed and synthesized, as well as the notes that reflect the ongoing inner thoughts, hunches, and reactions of the researcher" (Rudestam & Newton, 2007, p. 114). To preserve the integrity and confidentiality of the study, the researcher placed a copy of emails saved onto a compact disc in a locked filing drawer in her dissertation director's office. The IRB form, informed consent forms, signed consent forms were placed into a locked file cabinet in the dissertation director's office.

Second, to keep the files secure, the electronically recorded interviews were transcribed verbatim and saved on a password protected computer. The researcher labeled all of the electronic copies of the transcribed interviews and placed them in the same compact disc file in the same locked file cabinet in the dissertation director's office. The names of the participants and locations were deidentified by using pseudonyms to keep the anonymity of the participants.

Henceforth, all of the names of the participants were changed to pseudonyms to protect the participants' identities. A key linking the pseudonyms to the participants and their demographic sheets was prepared separately and located in a locked, secure drawer within the dissertation director's office. Third, the data was analyzed by question using data displays and memoing to derive meaning and find themes. Finally, the qualitative data analysis program, Maxqda was used to code the data (e.g. transcripts) and develop patterns consistent with qualitative data analysis (see Lofland & Lofland, 1995).

Data Quality

This section discusses strategies to check data quality. It first describes literature on data quality in qualitative research. It then examines how the researcher obtained credible data for the study. Beginning with previous research on data quality, researchers can implement procedures to ensure that data quality is valid, credible, and trustworthy. For example Creswell (2003) points to eight approaches to making data credible and valid including, (1) triangulation, (2) member-checking, and (3) thick description. Other ways to make data credible include: (4) explanation of bias on the part of the researchers who conducts the study, (5) prolonged engagement in the field, (6) peer debriefing, (7), negative cases, or (8) having an external auditor of the project. Similarly, researchers suggested that “prolonged engagement [in the field], persistent observation, triangulation,” member checks, peer debriefing, and finding negative cases are ways to establish trustworthiness or rather credibility to research (Lincoln & Guba, 1985, p. 301).

Consistent with the above research, the first way that the researcher addressed the issue of data quality was spending time getting to know the African American women participants, beginning with the unstructured interviews at Town University. After the second or third

interview, the participants became comfortable with the researcher. This resulted in having longer conversations off-the-record after the interview session was complete for the day. These conversations lasted from 30 minutes to three hours. This prolonged engagement in the field contributed to richer data in the third and/or fourth interviews centered specifically on the participants' experiences at Town University .

Second, the data was triangulated by utilizing multiple data sources, including the journal entries and interviews. Private documents (e.g., journals, diaries, and letters) are credible because they “enable a researcher to obtain the language and words of participants” (Creswell, 2003, p. 186). This form of data was also a thoughtful representation from the respondents. Third, member-checking was another way that the researcher attempted to make the research more credible. In an effort to verify accurate data, the researcher gave the participant the transcribed interviews to review and note changes in terms of the wording or phases in an effort to make the data more credible and valid. Some participants verified their transcripts in a timely manner, while others never responded. This might be an effect of less availability due to busy schedules and/or closure with the project.

Fourth, negative cases¹⁷ were used to check the data quality. This explorative multiple case research study had 16 African American women participants. Eight participants remained in hard science majors and the other seven departed the hard science majors and transitioned into social science or health science majors with the exception of one who was in the process of transferring from health science to Chemistry. The main purpose for having this high number of participants was to see if there were differences in the availability of cultural capital, science identity formation, experiences in the science culture due to multiple identities, and commitment

¹⁷ Negative cases prove that the same situation does not always occur with different cases (Rudestam & Newton, 2007).

to hard science majors. Even with the recruitment challenges, the researcher continued to find additional participants, some of whom provided additional insight that contradicted or complimented the findings from the first eight cases from phase one and phase two of the research study.

Finally, the aforementioned audit trail took the form of a journal noting the data analysis procedures and, more specifically, the coding and researcher biases. Consistent with previous research on validity and credibility (see Creswell, 2003; Rudestam & Newton, 2007), prolonged engagement in the field, triangulation, member checking, finding negative cases, and research bias contributed to the credibility of the current study.

Limitations and Delimitations of the Study

This section describes the limitations and delimitations of the study. While limitations refer to “potential weaknesses of the study” (Creswell, 2003, p. 148), delimitations “narrow the scope of a study” (p. 148). One limitation of the study was the use of purposive sampling, which limited the participants of the study to a particular program (e.g., Success Retention Program, Town University Leaders Program), student organizations, and/or participants who utilized the Sankofa Home as a resource. If African American women discarded the emails sent by those programs, then they missed the opportunity to participate in the current research study. Participant referrals through word of mouth, otherwise known as snowball sampling methodology (see Taylor & Bogdan, 1998) might have enabled the researcher to capture more participants in a timely manner.

A second limitation was the use of qualitative research to understand African American women and their experiences in hard science majors and classes. Qualitative research is not generalizable to larger populations like large scale quantitative research studies due to the small

population (Krathwohl, 2004) in this instance other undergraduate African American women's experiences in STEM fields at PWIs. Therefore, the findings from this study cannot be generalized to other PWIs. More importantly, a third limitation of the study was confining the data collection methods to interviews and journals. The data collection strategies did not enable the researcher to observe the participants or other African American women in upper-level hard science, social science, or health science classes in order to determine the nature of this populations' participation in class or even during their professors' office hours.

To add to that, two delimitations of the study were time (e.g. nine months) and resources. Due to time, other PWIs were excluded from this study. Resources were also limited given that the researcher relied on a handful of individuals to solicit participants for the study. Beginning in September 2011, the recruitment of participants using these individuals' marketing email vehicles became less of an option. It was not that the researcher abused their services, but rather that the former recruiters needed to tend to other job responsibilities. As a result, these limitations resulted in a delay in data collection for the researcher.

Resources and time also limited the scope of research to students and prevented the interviewing of the students' parents who are an important part of the neighborhood and school contexts. Parents made decisions shaping the participants' experiences inside and outside of school prior to their attendance at Town University. Interviews with parents could have generated an additional set of data to triangulate the data to confirm whether or not the participants told the truth, especially in K-12 settings. The interview protocol did not specifically ask about the influence of parents on the persistence of African American women in science majors, which is a delimitation of the study as well.

Furthermore, the study was confined to African American women in hard science majors or those who transferred from hard science majors to social science majors or health science majors. Therefore, this limited scope resulted in a smaller pool of African American women for the study, instead of women from the liberal arts, urban planning, individually designed majors, media studies, etc.

Researchers' reflection on the Insider/Outsider Perspectives

This section discusses the researchers' insider and outsider perspectives. Previous researchers have discussed their researcher biases through using the insider/outsider perspectives (see Jefferson, 2006). According to Schwandt (2000) "an internalist or insider perspective holds that knowledge of the social world must start from the insider or social actor's account of what social life means" (p 128). On the other hand, "an externalist or outsider perspective argues that knowledge of the social world consists in causal explanations of human behavior" (p. 128). What follows is a discussion of the researcher's insider and outsider backgrounds.

In spring 2011, I began collecting data for my dissertation on the persistence of African American women in Science majors at a PWI, Town University. Prior to conducting the first interview, I pondered the question, what biases do I bring to the study from an insider perspective? First, I am an African American woman and I am studying the population of African American women. Perhaps my identities of race, gender, and youthful appearance allowed some of the women to relate to me. I remember one participant was excited to learn that I was an African American female researcher. So, representation might have been important, because I might have served as a possible role model to her. I also had an emphatic spirit, non-judgmental mindset, which allowed me to relate to the participants, often referred to as the *sensational 16*.

Second, I attended predominantly white schools all of my life from elementary school throughout college and graduate school (with the exception of one year in elementary school in which I went to a predominantly Black school in Oklahoma City). With my insider knowledge on being an African American woman who graduated from a predominantly white college, I instantly related to the African American women in my study. So, it was easy to turn off the digital recorder and listen to their stories or even allow them to vent about certain situations. Perhaps my gender allowed me to appear to be *big sister* who listened to the *little sisters* (my participants') stories.

Third, my field of interest is a conflict. While I am in the field of education now, I wanted to be a nurse when I grew up until I saw the sitcom, E.R. in the 1990s. I despised needles and blood as well. To add to that, in my senior year of high school, I decided that I wanted to become a business major, so I applied to four colleges with the mindset that I was going into business. I got into all four colleges. Since business was not really my dream career, but rather I was persuaded by a relative to go into that major, I decided in my first year of college, that business was not for me. I saw some of my pre-Med African American female friends struggle in pre-calc and calculus at the University of Michigan as well.

Then, I fell in love with Psychology. So, that became my major. Psychology is a social science major as well. So, my background makes it understandable why I wanted to study African American women who departed or remained in the sciences. I used to be interested in nursing and even the quantitative major of business, more specifically accounting. So, my study on the persistence of African American women in hard science majors was personal. As I reflected on the interview sessions with some participants, I realized that their stories of trials and triumphs were similar to mine. I also observed that some of my participants emphasized the

need for mentorship and representation with the inclusion of more African American women in hard science majors.

Besides my insider background, I was an outsider in the study. I was seven to eight years older than the participants. So, I knew that my experiences at a PWI might be different from theirs. From the participants' stories, I learned that Town University was a different environment from the University of Michigan as well. Second, I was a college graduate and finished my master's degree. This was different from my participants who were in pursuit of bachelor's degrees. Since the study, four of the *sensational 16* graduated from Town University. Of the remaining participants, seven will graduate in May 2012. It is my hope that 100% of my participants graduate with bachelor's degrees by December 2013. Third, I dressed differently from my participants. I dressed like a professional with slacks, sweaters, and dress shoes. For the most part, they wore jeans and t-shirts. At one point and time later in the interviews, I realized that some of the *sensational 16* participants started dressing up at our meetings.

Finally, the majority of my participants were raised or at one time lived in a city. I informed them that I was not a city girl and that I was from a college town, Norman in the state of Oklahoma. So, my understanding of the K-12 educational system and neighborhoods was different due to geographic location. I thought that my outsider perspective would have given me the greatest challenges. After the study, I realized that my outsider background enhanced the study, because I was unaware of some of their experiences in cities, rural areas, or even suburbs. So, I was grateful that the *sensational 16* welcomed me with open arms to better understand their experiences.

CHAPTER 4

CASE PROFILES

This chapter presents a detailed description of each participant in the multiple case research study. It is organized in three sections. These include: (1) participants' characteristics, (2) multiple case study participants' descriptions, and (3) a concluding summary. Section 1 is an overview of the collective characteristics of the participants. Section 2 discusses the participants' personalities, science interests, family background, neighborhood context, educational attainment of family members, participant's high school college preparatory courses, and their college standing and activities at Town University. More specifically, the family background describes siblings (if any), household structure, family gatherings, and family travel.

Following is a description of their family backgrounds and neighborhood contexts. This section provides a description of the neighborhood and/or city that each participant resided in when growing up. It also uses statistical data from the 2000 U.S. Census Bureau to provide a clearer picture of each participant's town, city, or suburb. The American Fact Finder from the U.S. Census Bureau gave current data on the income of residents from specific cities, suburbs, and rural areas (see U.S. Census Bureau, 2009). The quantitative data drawn from the U.S. Census Bureau included information on the minority/white population, household size, marriage population, employment, median family income, percentile of families in poverty, and educational attainment of the population. Next is a discussion of the educational attainment of the participant's families. The section ends with a discussion of college preparatory curriculum offered by each participant's high school. The National Center for Educational Statistics provided data on student demographics and high school curriculum.

Section 3 is a concluding summary about the African American women participants' family, neighborhood, and school contexts that might contribute to them remaining or departing from hard science majors at Town University. More specifically, this section describes the similarities and differences between African American women in hard science majors who stayed and those who forewent hard science majors to transfer into social science or health science majors.

Participants' Characteristics

This section discusses four significant findings on the collective participants' characteristics based on a review of their demographic backgrounds, family, neighborhood, and school contexts. First, the multiple case research study participants' ages ranged from 19 to 22 years old, which is the standard college age population. They were also all full-time college students. Second, the majority of participants lived in two-parent homes (See Table 1). However, some participants' household structures were single-parent, a foster family, and/or extended-families (See Table 1). In addition, the majority of their parents worked in the service industries (e.g., postal services, autoworker, hospital, and carpenter) (See Table 1). A few of the African American women's parents held professional positions as teachers, entrepreneurs, and nurses as well (See Table 1). The nonworking parents were deceased, retired, unemployed or homemakers (See Table 1).

Third, Table 1 showed that about 60% of the participant's mothers earned college degrees. Of the college-educated mothers, four held master's degrees, four earned bachelor's degrees, and one obtained an associate's degree. The remaining mothers had at least a high school diploma. They also might have attended college, but never completed their degrees. In contrast, the participants' fathers earned fewer bachelors and advanced degrees. Consider for

example that two participants' fathers received master's degrees and two held bachelor's degrees. The other twelve fathers earned a high school diploma. Of the fathers whose highest education was a high school diploma, six of them went to college, but never finished.

Fourth, about 70% of the participants attended public schools while the other 30% went to private high schools. Of the eleven participants who enrolled at public schools, seven attended predominantly minority public schools, three studied at racially –mixed high schools, and one received instruction at a predominantly white school. In contrast, three participants who attended predominantly white private schools and the other two went to primarily minority private schools.

Furthermore, the majority of participants were juniors and seniors at Town University. An exception to the rule was one participant who was a rising sophomore about to enter her junior year at the time of the study. In addition, 40 percent of the participants were first-generation college students while the other 60 percent were second-generation college students. Moreover, two of the participants stopped-out from Town University after their first year of college. There were also two participants who transferred from other institutions to matriculate at Town University as upperclassmen. Finally, in this initial analysis about 30 percent of the participants remained in their initial majors. They transitioned to a different hard science major, social science major, or health science major. An exception to the rule was one participant who was in the process of moving up from the health science major to chemistry, a hard science major.

Table 1: Overview of the Participants

Name	Age	First College Major	Final College Major	College Standing
Regina	20	Pre-Business	Sociology	Junior
Briana	20	Biochemistry	Biology	Junior
Shannon	19	Biology	Biology	Sophomore
Carmen	22	Biology	Sociology	Senior
Ashley	21	Biology	Biology	Senior
Jennifer	21	Mathematics	Mathematics	Senior
Celeste	22	Pre-Business	Sociology	Senior
Amber	20	Biology	Health Science	Junior
Raven	20	Biology	Health Science	Senior
Patricia	21	Business	Business	Senior
Simone	22	Engineering	Engineering	Senior
Crystal	21	Biology	Health Science	Senior
Danielle	19	Biology	Health Science	Junior
Kayla	20	Health Science	Chemistry	Junior
Rachelle	21	Biology	Biology	Senior
Lara	21	Mathematics	Mathematics	Junior

Table 1 (cont.)

Mother's Education	Mother's Occupation	Father's Education	Father's Occupation
Master's Degree	Teacher	H.S. Diploma	Truck Driver
H.S. diploma	Housewife	H.S. Diploma	Landscaper
Associate's degree	Registered Nurse	Some College	U.S. Steel Security & Fire Services
Bachelor's	Nurse	Master's	Firefighter
Some College	USPS Worker (mail carrier)	H.S. Diploma	City/ Water Dept.
Master's Degree	Homemaker	Master's	Entrepreneur
Some College	USPS Worker (mail carrier)	Some College	Veteran's Affairs Hospital Worker
Bachelor's degree	Unemployed	Some College	Auto worker
H.S. diploma	Supervisor (Hotel)	H.S. Diploma	Retired Carpenter
Some College	USPS Worker (mail carrier)	Some High School	Deceased
Master's Degree	Teacher	Bachelor's degree	Systems Analysis
Some College	Retired	H.S. Diploma	Self-employed painter
Bachelor's degree	Computers	Bachelor's degree	Computers
Some College	Unemployed	Some College	Unemployed
Bachelor's degree	Pharmaceutical Sales	Some College	Auto worker
Master's Degree	Director of Mental Health Care Center	Unknown	Deceased

Multiple Case Research Study Participants' Descriptions

Case 1: Regina

Regina was a soft-spoken and reserved African American woman. She recalled being interested in business at the tender age of eight after playing with cash registers. At this time she had an infatuation with business suits, briefcases, and cell phones as well. Moreover, throughout the interviews, she continued to deliver *safe* answers, which was perhaps due to being an introvert. This point was illustrated through her narrative on the family context. For example, she recollected being the youngest child who grew up in a single-parent family comprised of her mom and three siblings. Family gatherings consisted of meal preparation at her mother's home for holidays like Christmas. Although she came from a lower-middle class family, her family traveled to the East Coast, West Coast, and the South for vacations.

Equally as important was the neighborhood context. For instance, Regina lived in Statesville from age five to the present. From age fifteen to now Regina lived in a family centered neighborhood in Statesville. She remembered Statesville being a diverse city. However, the U.S. Census Bureau (2000) reported that Statesville comprised of 65% whites and 35% minorities in the 1990s. The average household size was four people; and about 60% of women and men were married as well. Additionally, 65% of people ages 16 or older held jobs. Furthermore, the median household income for families in Statesville was \$65,000 between 2005 and 2009 (U.S. Census Bureau, 2009). Likewise, less than 10% of the families lived below the poverty line in her city. Furthermore, in Statesville, 90% the people in her town held a high school diploma and 35% earned a bachelor's degree.

Consistent with Statesville's population, Regina's mother obtained a bachelor's degree. In fact, she graduated with a teaching degree in biology (a hard science field) from a minority

serving institution. Her sister also completed college. At the time of the study, her brothers worked on degrees at technical colleges. Similar to her family, the majority of her neighborhood peers went to college with the exception of one peer who became a teenage mother. The majority of her public high school friends attended college as well. This was understandable, due to the fact that her predominantly minority, suburban high school offered advanced placement and honors curriculum (National Center for Education Statistics, 2010).

In 2008, Regina entered Town University as a freshman interested in a pre-business major. After first year, she took off a semester from Town University due to financial concerns. Then she enrolled at a community college. At the time of the study, Regina was a junior majoring in sociology with a minor in African American studies. During the spring 2011, she took sociology classes for her major and African American studies classes for her minor. Her main obligations were school and working with women's organizations on campus. In the fall 2011, she was excited to report her upcoming graduation from Town University in spring 2012.

Case 2: Briana

Briana was an African American woman with a bubbly and outgoing personality. She always came late to the interviews with a smile on her face in spite of her personal and academic challenges. To illustrate, she was enthusiastic when describing her science interests. She also remembered being interested in science around age 7 or 8 after attending a special space program at a research intense university for gifted and talented elementary school students. Similar to her openness in describing her science interests from day one to the last interview, she was very open and honest. For instance, she revealed that she was adopted by a working-class African American foster family in Central City Heights. She resided with them from birth to age 15. In fact, she paralleled her life story to the movie, *The Blind Side*. She recalled her neighbors being

African American and Mexican in Central City Heights. She described Central City Heights as diverse.

Growing up with the African American family, she recollected family gatherings and travel consisted of leaving town to other Midwestern states or the South for funerals. However, her life changed at age 16 when she transitioned from her African American foster family into a children's shelter. Then, she moved to Townville Heights to live in a foster home with lower-middle class white parents and their son.

Similar to Briana's description of Central City, according to U.S. Census Bureau (2000) Central City Heights was a diverse city with a population comprised of 60% minorities and 40% whites. In addition, the family household size was three and a half people. The marriage population was about 40% of men and women as well. Furthermore, approximately 60% of people 16 or older were employed in the 1990s. Likewise, the median household for families in Central City Heights was less than \$50,000 (U.S. Census Bureau, 2009). To add to that, less than 10% of families lived under the poverty level. To end the neighborhood context description, the educational attainment follows. In Central City Heights about 75% of the population ages 25 or older held a high school diploma while less than 15% earned a bachelor's degree.

Consistent with the population of Townville Heights both of her white foster parents (both deceased) earned high school diplomas. Additionally, her white foster brother graduated from college. However her foster sister from her Black family never attended college. This was congruent with the educational attainment of people from Central City Heights. Similarly, some of her neighborhood peers from Central City Heights and Townville Heights matriculated at community colleges. However, none of these friends attended four-year institutions.

On the contrary to Briana's neighborhood peers, she went to a racially-mixed, suburban public high school with a gifted program and honors and advanced placement curriculum to prepare students for college (National Center for Education Statistics, 2010). In 2008, she entered Town University as a biochemistry major. As a junior in spring 2011, she majored in biology and minored in chemistry. She took biology, chemistry, theatre, and statistics classes as well. Outside of classes, she engaged in the organization Relay for Life; volunteered at a food bank, engaged in research in a lab, and worked 15 hours between two jobs. In fall 2011, she informed the researcher that she would be graduating in spring 2012.

Case 3: Shannon

Shannon was a soft-spoken, friendly, and assertive African American woman. She developed an interest in science in fourth grade due to her instructor and exposure to science labs. Equally as important, Shannon was a reserved person. However, she shifted into a more open and honest person during the third interview on her college experiences. For example, she described the challenges studying for science and math classes, due to the fact that she never studied in high school. Similarly, she disclosed being the youngest of the three children in lower-middle income two-parent household. She also recalled family gatherings centered on meeting with relatives during the holidays and summer in her home. As a child, she traveled with family members to the West, West Coast, and the South as well. Additionally, from her teenage years to early adulthood, she traveled with family members to the South. She also went on cruises in the United States and overseas with relatives as well.

In addition to the family context, the neighborhood context was important to understanding Shannon's schooling experiences. She was born in Central City. She lived there up to 12 years-old. At that time in Central City, she described her neighborhood as being African

American, peaceful, and quiet. She also associated with Black female friends who lived in middle-class, single parent homes, blended families or two-parent households. Around age 12 her family moved to the suburbs of Redford Heights. She observed the neighborhood to be diverse with younger and older African American families.

To complicate the neighborhood context, the U.S. Bureau (2000) reported that Central City had a majority white population in the 1990s. The average family household size was three people. In addition, 50% of men and women were married. Moreover, approximately 55% of the population ages 16 or older held jobs. The median income of families was less than \$50,000. Less than 5% of families lived below the poverty level as well. Furthermore, 75% of people in Central City held a high school diploma and less than 10 percent obtained a bachelor's degree.

Consistent with the Redford Heights educated population (U.S. Census Bureau, 2009) both of her parents earned high school diplomas. Her mother also completed a two-year associate's degree in nursing (a health science field). In addition, her father attended college, but never finished due to military obligations. Occasionally, her older brothers took college classes. Similarly, the majority of neighborhood kids (approximately 15 to 20) enrolled in college. Likewise, based on the Redford Heights population, Shannon was destined to attend college.

Prior to college, Shannon attended a low-income, predominantly minority, suburban high school (National Center for Education Statistics, 2010). It offered several advanced placement science courses and a handful of advanced placement courses in math, English and social studies. After high school in fall 2009, she became the first person in her family determined to complete a four-year degree in biology at Town University. At the end of spring 2011, she finished up sophomore year as a biology major. She took a chemistry, biology, psychology and a human development class. Outside of classes, she participated in an international organization that

fundraised to build clinics for children. She also served as the caregiver of children when the teen mothers participated in support groups. More importantly, she sacrificed working a job to focus on her major during her freshman and sophomore years of college. However, in fall 2011, she continued engaging in the biology major, worked at a job, and participated in leadership roles in student organizations at Town University.

Case 4: Carmen

Carmen was from Panama, but she identified as African American. She was a very talkative person with a pleasant or moody attitude. For instance, she was very enthusiastic when telling her story about her science interests. To illustrate, she described her leaf collection in grammar school. She also discussed her interests in science in sixth grade after being exposed to an oncologist inside a middle school classroom and her mother's diagnosis with cancer. After interview two she had less of an attitude during the interview sessions. This might be in part due to her feeling comfortable.

Equally as important was her family context. She grew up as the youngest child in a working-class, two-parent household with one biological brother and cousin who she considered to be a brother. Her family traveled across seas to visit family members, but they rarely took family vacations, due to their social class. It was not until high school when her parents traveled on cruises, because they moved from a working-class to lower-middle class social background after completing college degrees.

To add to Carmen's story, it was important to describe her neighborhood context. She remembered being the *only* Black family in a predominantly white neighborhood in South Town. However, she recalled that over the years the demographics of the population changed to being more violent with a diverse population. Consistent with her description South Town was 80%

white and 20% minority (U.S. Census Bureau, 2000). Additionally, the average household size for families was three people. In South Town, 55% of males were married when compared to 45% of females as well. Moreover, approximately 70% of the population ages 16 and older were employed in South Town from 2005 to 2009 (U.S. Census Bureau, 2009). It also had a median family income of less than \$60,000. So it was understandable that less than 10% of families lived below the poverty line. Furthermore, about 90% of the people in South Town held a high school diploma while less than 25% of people ages 25 or older earned bachelor's degrees.

Similar to South Town's population Carmen's parents completed high school diplomas. In addition her mother finished a bachelor's degree in nursing (a health science field) and her father completed a master's degree in civil and mechanical engineering (a hard science field). Unlike her parents, her brother did not attend college. Additionally, the majority of Carmen's neighborhood peers refused to matriculate in college. However, she remembered the big celebration of one African American female peer that graduated from college.

Equally as important was that Carmen encountered several challenges in schools, which ultimately led to her receiving home schooling up to 3rd grade. She later attended private schools for grammar school. Then, she went to a private high school. After that, she attended a racially-mixed, suburban high school that offered a handful of advanced placement courses (National Center for Education Statistics, 2010). However, students earned college credit from the neighboring community colleges or four-year institutions. So it was understandable that after high school Carmen attended a community college. After acquiring better study habits she matriculated at a private predominantly white college down South. Then, she transferred to a Historically Black College and University, due to the chilly racial climate at the other private white college.

In spring 2010, Carmen transferred to Town University as a junior. At that time she was a biology major preparing for medical school. A year later in spring 2011, she was a senior majoring in sociology, because she was unable to fully complete the biology requirements at Town University. For the spring 2011 term, she elected classes including: an international health policy class, geography of health care, and a social theory class. She also worked a full-time job averaging 40 hours per week and volunteered at a hospital. In December 2011, she graduated from Town University with a bachelor's degree in Sociology.

Case 5: Ashley

Ashley was a confident yet reserved and soft-spoken biracial woman. She identified as an African American woman, mainly because of her Black Cuban father, but her mother was white. To add to that, she became interested in science in high school. During that time, she engaged in more laboratory experiments, because her high school had excessive resources unlike her previous schools. She was also very open during interview one when describing her family background and neighborhood contexts. For example, she grew up as the middle child of three children in a working-class, two-parent household. She recollected family travel consisting of visits to the Midwest to see family members. Outside of that, her family rarely traveled due to their social class standing.

In addition to the family context, Ashley's neighborhood context contributed to her schooling experiences. To demonstrate from newborn to age 6, she described her neighborhood as diverse with Asians, African Americans, Whites and young families on the Westside of Central City. Then from ages 7 to 8, she lived in a predominantly Black neighborhood on the Westside of Central City. Today, her parents live in a low-income neighborhood comprised of

Blacks, Indians, and Pakistanis in Central City. Furthermore, she discussed that there were gang members, shootings on a regular basis, and teenage mothers in the neighborhood.

The U.S. Census Bureau (2000) also reported that the Westside of Central City is diverse with 50% whites and 50% minorities. In addition, the average household size for families was three and half people. Less than 35% of men and less than 45% of women were married as well. More importantly, approximately 80% of the residents ages 16 or older were employed on the Westside of Central City (U.S. Census Bureau, 2009). The median family household was about \$45,000. The family income coupled with the employed population made it understandable that less than 10% of families lived below the poverty line. Another significant statistic was that approximately 75% of people held high school diplomas and 20% acquired bachelors' degrees on the Westside of Central City.

Comparable to Central City's educational attainment, Ashley's parents obtained high school diplomas. Although her parents did not complete college degrees, all of her siblings attended college. Additionally, she had one family member who finished a degree in agricultural sciences (a hard science field) at a four-year institution. Similar to her neighborhood and family background, she recalled that one neighborhood peer attended and graduated from college. However, the educational choices of Ashley's parents provided her with tools to successfully transition into Town University as a biology major.

Consider the fact that Ashley attended a private white, college preparatory high school that offered multiple advanced placement courses to prepare students for college (National Center for Education Statistics, 2010). In 2007, she entered Town University as a freshman interested in biology. In spring 2011, she was a senior majoring in biology. She enrolled in three dance classes and a biology class. She also engaged in laboratory research, participated in Black

student organizations, worked on a senior thesis, exercised, and devoted 10 to 20 hours per week for the job in a dining hall. In the fall 2011, she entered a PhD program in biology at a research intense university. She continued her studies in the PhD program in spring 2012.

Case 6: Jennifer

Jennifer was an outgoing and talkative African American woman. She became interested in math in fifth grade, in part due to her successes with the math problem of the week. Plus her social and friendly personality might have contributed to her being open from interview one when describing her family background and neighborhood contexts. For instance, she discussed being the oldest child in a middle class two-parent family, which comprised of her mother, father, and brother. She also stated that she was a daddy's girl while her brother was closer to her mom. Moreover, she remembered family gatherings with her mother and brother, because her father was absent due to traveling for work. Her family traveled to the West, West Coast, East Coast, Midwest, and the South. Outside of the United States, she traveled to Mexico and the Bahamas with family members as well.

Beyond the family context, Jennifer's neighborhood context might have accounted for her smoother transition into predominantly white school contexts. More specifically, she resided in a Jewish suburban neighborhood. She described her neighborhood in Southwest City being predominantly white. However, Southwest City was racially-mixed with 55% minority and 45% white residents in the 1990s (U.S. Census Bureau, 2000). The average family size was three people. Forty percent of the married population consisted of men and women. Additionally, about 60% of the population ages 16 or older held jobs. This might have contributed to the median family income of less than \$45,000. Furthermore, fewer than 25% of families lived

below the poverty line. However, in Southwest City 70% of people held a high school diploma and less than 20% obtained a bachelor's degree.

Inconsistent with Southwest City's population, Jennifer's parents were highly educated with advanced degrees. Her mother has a Bachelor's degree in marketing (a hard science field) while her father has a bachelor's degree in architectural engineering (a hard science field) and a master's in business (a hard science field). So, it was understandable that Jennifer (a college senior) and her brother (a college sophomore) attended college. Similarly, she recalled that all of her neighborhood peers attended college,

Likewise, Jennifer's parents sent her to predominantly white schools in primary and secondary schools. As a consequence, she remembered being *one of the few* African American girls in her classes from elementary school throughout high school. However, the private high school that she attended offered multiple advanced placement courses to prepare students for college (National Center for Education Statistics, 2010). Hence in 2007, she began her journey in college as a mathematics major at East Lake University, a predominantly white institution on the East Coast. Consequently, two years later in 2009, she transferred from East Lake University to Town University, due to homesickness, causing her to miss her family. In spring 2011, Jennifer was a rising senior majoring in mathematics. She enrolled in mathematics, economics, and a physical science class. She was also a very busy woman who participated in organizations from honor societies to volunteer organizations. In May 2011, she graduated from Town University as *one of the few* African American math majors. By November 2011, she was working as a financial advisor at a company. So, she remained working in a STEM community post-graduation.

Case 7: Celeste

Celeste was a soft-spoken African American woman who once aspired to become a doctor. Her interest in a career as a doctor waned after dissecting a pig and squid in school. Similar to describing the science interest, she was open when discussing her family and neighborhood background. Celeste claimed that she came from a working-class, single-parent family headed by her mother, due to her parents' divorce. She was the middle child of six as well. She also remembered family gatherings for holiday meals (e.g., Thanksgiving, Christmas, and New Year's) and/or funerals with her mother and five siblings (e.g., three sisters and two brothers). When her father was in the home, the family traveled to Disney World when she was around the tender age 10 or 11 years-old. Her parents divorced after that trip. This resulted in fewer family trips due to financial reasons. However, school trips enabled Celeste to travel with peers to Midwestern states, the South, and the East Coast.

Equally as important as her family context was the neighborhood context. She described the African American neighborhood filled with crime, teenage mothers, and poor or working-class single-parent mothers with boyfriends living in their homes. In contrast, her mother was considered to be doing better than other mothers, due to being employed and her marital status with a husband with a two person income. However, her mother later divorced her father and then became a single-parent mother raising six children.

Comparable to Celeste's description of her city, according to the U.S. Census Bureau (2000; 2009) the Westside of Central City has been less than 50% white and more than 50% minority from the 1990s throughout 2009. The average family household size was three and a half people. The majority of men and women were not married. Consider for example that less than 35% of men and 45% of women were unmarried. In addition, about 80% of the population

ages 16 or older worked. However, the median household family income was approximately \$45,000 in 2009 (U.S. Census Bureau, 2009). Less than 10% of families lived below the poverty line as well. Moreover, on the Westside of Central City approximately 75% of people ages 25 or older held a high school diploma while about 20% of people earned a bachelor's degree.

Similar to the Westside of Central City's population Celeste's mother and father earned high school diplomas. However neither her mother nor father completed a college degree. On the contrary, her aunt earned a doctorate in nursing (a health field). Despite this educational success in her family, she remembered that fewer than 20 people in her neighborhood attended college. Unlike her neighborhood peers, the educational choices that Celeste's mother made might have contributed to her preparation for college.

Consider for example that instead of attending the neighborhood high school, Celeste's mother sent her to a private predominantly minority high school, which prepared 100% of students for college (National Center for Education Statistics, 2010). However, this high school offered a handful of advanced placement and honors courses. Despite the limited number of in college curriculum offered to students, Celeste entered Town University with an interest in business in 2006. Suddenly by the end of freshman year, Celeste realized that the demanding curriculum at Town University differed from her high school. She neglected studying in high school. So, she stopped-out for a year from Town University. During that year she went to massage school.

By 2008, Celeste reentered Town University as a sophomore eager to find a major for her. In spring 2011, she was a rising senior majoring in sociology. She took a criminology class, a labor employment class, and an educational psychology class. Since she had scholarships, she was unemployed to focus on her heavy course load of 21 hours. She discussed that her daytime

schedule consisted of going to class, doing homework, sleeping, and eating. In May 2011, she became the first person in her immediate family to graduate from college. In our follow-up meeting in the summer 2011, she admitted the desire to pursue a doctorate. By December 2011, she finished up the first semester of a master's program in Sociology at a public research institution.

CASE 8: Zaria

Zaria was case number 8 because of her willingness to engage in a phone conversation about the study. In the phone conversation, she gave oral consent to participate in the study. Zaria was omitted from the study, because the researcher never obtained written consent from her to engage in the study. The researcher engaged in a number of outreach techniques through calling and emailing her, but Zaria was unresponsive. Every time the researcher attempted to fill the slot in case number 8 with another participant, the prospective candidate dropped from the study. So, the researcher added an additional participant to the study. Zaria remained as case number 8 to acknowledge challenges with securing participants in qualitative research in the data collection phase. The researcher also recognizes Zaria's contributions to qualitative research even though she elected to withdraw from the study. Other qualitative researchers remembered participants who departed their studies as well (see Evans-Winters, 2005).

Case 9: Amber

Amber was an African American woman with a very outgoing and assertive personality. So, it was easy interacting with her during the nine interview sessions. In the second session, she discussed that her science interest began in sixth grade, due to her family members' health conditions. She continued to open up during latter interview sessions. For instance, in session three she discussed challenges transiting into a racially-mixed high school and new town.

Equally as important was the family context and neighborhood. Amber grew up in a working-class two-parent household with five younger siblings. She recollected family gatherings consisting of barbeques, large parties, holidays and family reunions. Her family traveled to the Midwest and the South as well.

Besides the family context, Amber's neighborhood context was important to understanding her latter schooling experiences. She grew up in Southville Heights from birth to age 17. She remembered the racially-mixed population with Black and white residents. She also recalled a lot of kids in her neighborhood. However, she recollected that Townville Heights was predominantly white. Consistent with Amber's description of Southville Heights, about 20 % of people classified as white while approximately 80% identified as minority (U.S. Census Bureau, 2000). The household size was three people. About 70% of men and 55% of women were married as well. From 2005 to 2009, about 70 percent of people ages 16 and older were employed (U.S. Census Bureau, 2009). This might have accounted for the median family income of about \$55,000 and fewer than 10% of the population living under the poverty line. Moreover, over 80% of the people in Southville Heights held high school diploma and 25% obtained a bachelor's degree.

Comparable with Southville and Townville's (U.S. Census Bureau, 2009) population Amber's parents held high school diplomas. However, her parents earned associates degrees at community colleges. By the end of the study, her mother graduated college with a bachelor's degree in nursing (a health science field) in summer 2011. In fact Amber's mom was the first person in the family to attend and graduate from college. Plus her father worked as a mechanical engineer (a hard science field). Additionally, the majority of her relatives on her father's side of

the family completed degrees at HBCUs in the South. A couple of her relatives hold nursing degrees and medical degrees as well.

Similar to her family's educational attainment, she recalled that the majority of peers from her first high school attended college. All of her friends from the second high school went to college as well. This might be attributed to the fact that the racially-mixed high school offered advanced placement and honors curriculum to prepare students for four-year institutions (National Center for Education Statistics, 2010). More importantly, unlike some of her family members and school peers from Townville Heights, Amber was the first person in her family to attend a four-year research intense university.

In 2009, as a freshman, Amber was interested in majoring in biology to prepare her for medical school to fulfill the career aspiration as a medical doctor. She also wanted to create a dance studio to address the health needs of African American girls. So for spring 2011, she took chemistry, a health science class, and a dance class. She also participated in a couple of organizations on campus and she worked part-time. She declared biology as her major at the end of spring 2011. By summer 2011, she was considering transferring into the health sciences as a major to prepare for medical school. However, during this transition phase, she worked and retook a biology class. In February 2012, Amber reported that she was a health science major.

Case 10: Raven

Raven was a dependable and outspoken Jamaican who identified as an African American woman. She came to meetings in sickness and health. Her dedication and openness began during day one. By interview session two, she described her interest in science stemming from working on a science project centered on the heart at age 8. By reflecting she acknowledged that that project contributed to her passion and drive to pursue a career as a cardiologist. In a similar

fashion, she opened up to describe her family background. She grew up in a working-class, single-parent household as youngest of three children, two of whom are her biological brothers. By age five, she recalled that her brothers moved down South to live with their father. Suddenly, she became the only child living with her mom. As a consequence for family gatherings, she remembered the family dinners with her mom to celebrate Thanksgiving and Christmas. Family travel involved her mother, neighbors, and her going down South as well.

Similar to the family context, Raven provided a vivid description of her neighborhood context. She remembered the violence of people, shooting, gangs and teenage mothers in her predominantly African American neighborhood in a Central City. Despite Raven's neighborhood demographics, Central City was considered a predominantly white city with a population of 80% whites in the 1990s (U.S. Census Bureau, 2000). The average family household size was three people. About 50% of men and women were married at this time as well. Fifty-five percent of its population ages 16 and older were employed too (U.S. Census Bureau, 2009). However, the median family household income was less than \$50,000. Less than 5% of the population lived below the poverty level as well. Furthermore, 75% of the population held a high school diploma and less than 20% earned a bachelor's degree.

Consistent with Central City's population, Raven's parents completed high school diplomas. Her oldest brother also attended college, but he dropped out due to family obligations. None of her family members completed degrees in science or math. Similar to her family's educational attainment, she remembered that an African American woman friend attended college from her neighborhood. She left college due to having a baby as well. So, Raven was the first person in her family and neighborhood to persist in college. Unlike her the majority of her neighborhood peers, Raven attended a predominantly minority high school that offered advanced

placement and honors classes in science, math, English and social studies (National Center for Education Statistics, 2010). These courses might have prepared Raven for her studies at Town University.

In fall 2008, Raven began as a biology major at Town University. Three years later in fall 2011, she was a rising senior in health science. She took courses, including speech communications, biochemistry, and health. In her free time, she volunteered at a hospital or for her student organization. She was also a mentor in student organizations, and held leadership positions in health at Town University. Outside of student organizations, she worked at a hotel on the weekends. In spring 2012, she will be the first person in her immediate family to graduate from college. In Spring 2012, she reported being accepted to a post-baccalaureate program to prepare scholars for medical school.

Case 11: Patricia

Patricia was a soft-spoken, yet assertive African American woman. From the beginning of the interview sessions, she was an open and honest person. Consider for example, she spoke about always having an interest in math. In grammar school she remembered selling candy for a fourth grade class business project. Similarly, she was candid about her family background. She lived in a lower- middle class, extended family with her mother and grandparents as well. Although she had six siblings, she claimed to be an only child, due to the fact that she only lived with her mom. Her siblings lived with her father. As a result, she remembered family gatherings consisted of relatives congregating at her grandmother's house for holidays, like Labor Day, Memorial Day, Christmas, and Thanksgiving. Her family traveled to the Midwest and down South for family vacations as well.

Likewise, for the first twelve years of her life, she grew up with her extended family on the North side of Central City. She recalled it being a diverse city with whites and African Americans. She also remembered being a part of an afterschool program with her African American neighborhood peers. In addition, from age twelve to the present she lived in the suburbs of Central City Hills with her mother. She described Central City Hills as diverse with Mexicans, Arabs, and African Americans, and Whites.

However the U.S. Census Bureau (2009) reported that about 70% of Central City Hills were white and 30% minority. The average household size for families was about three people. Approximately 55% of men and 45% of women were married at that time. About 70% of people age 16 or older were employed as well. In addition, the median household family income was about \$70,000. So it was understandable that less than 15% of families lived under the poverty level. More importantly, 90% of the population held a high school diploma and less than 25% earned a bachelor's degree.

Similar to Central City Hills's population, Patricia's mother earned a high school diploma. However her mother began college to pursue a degree in biology to become a dentist, but she dropped out of college. She also recalled that one aunt finished a degree in cosmetology. None of her family members completed degrees in science or math. Comparable to her family background, few people in both neighborhoods that she lived in attended college. Unlike her neighborhood peers, Patricia enrolled at a predominantly minority college preparatory high school that offered multiple advanced placement and honors courses (National Center for Education Statistics, 2010).

In 2008, Patricia entered Town University as a freshman interested in business. Three years later in fall 2011, she was a rising senior at Town University. Currently, she took several

business classes and an information technology class. She also worked two jobs on the campus of Town University. Additionally, she was involved in student organizations and mentored younger students. More importantly, in spring 2012 she will be the first person to graduate in her immediate family and neighborhood with a degree in business.

Case 12: Simone

Simone was an assertive and talkative, African American woman with a bubbly personality. She came to every meeting cheerful and ready to talk despite her demanding schedule. For instance, she recalled that the science interest eventually developed in high school. She was open and honest in describing her high school experiences, which could be in part due to her vivid memory of those experiences. She remembered mixing chemicals and the reactions of those chemicals in the labs. Similarly, she was open in discussing her family background. She grew up in a middle class, two-parent family comprised of her mother, father, and brother. She also remembered that family gatherings comprised of food and fellowship with relatives for Thanksgiving, Christmas, the Fourth of July, Mother's Day and Father's Day. Family travel consisted of road trips to the South to visit family members, because her father despised air travel.

Once again she provided a thorough description of her neighborhood, Town Heights. She described it as a suburb with young families. She also felt as though the suburb comprised of majority Blacks and fewer whites. Consistent with Simone's description of Town Heights, the suburb was predominantly minority (U.S. Census Bureau, 2000). The mean family household size was three and a half people. It had a population with 55% married men and 45% married women as well. In addition, 65% of the population ages 16 or older were employed (U.S. Census Bureau, 2009). Moreover, the median household income for families was less than

\$65,000. However, less than 5% of families lived below the poverty level. In Town Heights about 90% of the population held high school diplomas and about 30% obtained a bachelor's degree as well.

Comparable with Town Heights' educational attainment, Simone's mother and father earned high school diplomas and college degrees. Her mom began her studies at Town University, but transferred to a different college. She also obtained an advanced degree and serves as a teacher. Her father went to a different PWI to complete a degree in computer science (a hard science field). On the contrary, her uncle completed a degree from a HBCU in the South. Similar to her family's educational attainment, she recalled that the majority of the neighborhood kids attended college.

In high school, Simone attended a predominantly minority high school. It offered advanced placement curriculum to students to prepare them for college (National Center for Education Statistics, 2010). So, it was understandable that Simone attended college given that she elected advanced placement courses in high school. In 2007, Simone entered Town University as an engineering major. For fall 2011, she was a rising senior majoring in engineering. She enrolled in engineering and food science courses. She was also a member of an engineering organization. She sacrificed other student organizations to devote the remainder of her time to school in fall 2011. In spring 2012, she will graduate from Town University.

Case 13: Crystal

Crystal was a talkative and friendly African American woman who came to every meeting with a smile on her face. She opened up in the first meeting discussing her participation in multiple organizations. Throughout the interviews, she continued to be honest about her educational experiences. For instance, she was always interested in science until her chemistry experiences in high school. She liked science because the curriculum centered on the body. In

another interview session, she spoke about being the only child in a lower- middle class, single-parent family until her mom married her stepfather. She also remembered family gatherings consisting of going to her grandmother's house for holiday dinners (e.g., Thanksgiving). She traveled with her family down South to visit family members and to the Midwest as well.

Similar to the family background, Crystal had a clear memory of her childhood surroundings. She described the Southern region of Central City as diverse. She recalled interacting with Whites, African Americans, and Mexicans in her neighborhood. Unlike her neighborhood in Central City, the statistics from the U.S. Census Bureau (2000) revealed that it was predominantly white in the 1990s. The mean household family size was three people. Fifty percent of men and women were married as well. Similarly, about 55% of the population ages 16 and older were employed (U.S. Census Bureau, 2009). However, the family household income was less than \$50,000. In addition, about 10% of the population lived under the poverty level. Approximately 70 percent of the population ages 25 or older obtained a high school diploma. Less than 10 percent held a bachelor's degree as well.

Consistent with Central City's population, Crystal's mother finished high school and some college. Her father earned a high school diploma as well. She also revealed that an aunt obtained a bachelors and master's degree from a minority serving institution in the 1980s. In addition, she spoke about a cousin who went to a PWI similar to Town University. However, none of her family members finished a degree in math or science. Similar to her family's educational history, only three neighborhood peers went to college.

Equally as important was that Crystal attended a predominantly minority and low-income, public high school. It offered a handful of advanced placement and honors classes in science, math, social studies, and English (National Center for Education Statistics, 2010). More

importantly, the curriculum offered through the public high school gave her the chance to succeed in college at Town University. On the other hand, it might have contributed to her challenges in the science curriculum at Town University. Consider for example in 2008 when Crystal entered Town University, she was interested in Pre-Med and the biology major to become a doctor. However, the biology curriculum and class structure contributed to her change in major to health science. In fall 2011, she was a rising senior at Town University taking health science classes, an internship, and a horticulture class. She also worked at a job and mentored youth through her involvement in student organizations at Town University. In spring 2012, she will be the first person in her immediate family to graduate with a bachelor's degree.

Case 14: Danielle

Danielle was an outgoing and religious African American woman. Beginning in the first interview, she opened up to share her story. Consider for example, her interest in science began at an early age. She also remembered enjoying science over subjects like English and social studies. In addition, she was very candid about her family background. She was born in Central City and grew up as the youngest child in a middle-class, two-parent family with three kids. She also recalled family gatherings centered on spending time with relatives on holidays, such as Thanksgiving, Christmas, Fourth of July, and Labor Day. Her family traveled to the South and East Coast for business meetings or vacations as well.

Besides Danielle's family background, her neighborhood context might explain her latter schooling experiences. For instance, Danielle lived in Central City from birth to age 11 in a middle-class African American neighborhood. Then her family moved to Statesville, a suburb. Her parents still live there in 2011. In early adolescence, she remembered there being more whites in Statesville than Central City. From adolescence to early adulthood, she recalled Statesville being a racially-mixed suburban town. She also recollected there being an African

American family in her neighborhood similar to her family composition with the wife, husband, and their older children.

Consistent with Danielle's description of Statesville, the U.S. Census Bureau (2009) reported that about 65% of the population was white and 35% minority. The household size of families was four people. Approximately 60% of women and men were married as well. Additionally, 65% of its population ages 16 and older were employed between 2005 and 2009. It also had a median family income of \$65,000. Fewer than 10% of families lived under the poverty level. About 90% of the city's population ages 25 or older earned a high school diploma and 35% obtained a bachelor's degree as well.

Comparable with Statesville's educational attainment both of Danielle's parents finished high school and college. Her parents hold degrees in computer science (hard science majors). In addition, her sister went to a small four-year institution. Recently, her brother enrolled in a community college after serving in the National Guard. Her uncle completed a degree in kinesiology (a health science major) and an aunt finished a degree in nursing (a health science major) as well

Similar to the educational background of her family, it was no coincidence that Danielle enrolled at a predominantly white, suburban high school. Her school offered multiple advanced placement and honors classes to prepare students for college (National Center for Education Statistics, 2010). In 2009, she entered Town University as a freshman majoring in biology. By fall 2011, as a junior Danielle transferred into the health science major at Town University. She took courses in subjects including biology and health science. Outside of class, she worked a couple of hours at a job, participated in the track team at Town University, and attended church on a weekly basis.

Case 15: Kayla

Kayla was a reserved yet friendly African American woman. Kayla always had a smile on her face in spite of the challenges that she faced due to her tight schedule and heavy course load. She was open and honest during the interviews when discussing science interests, along with family and neighborhood backgrounds. For instance, she developed an interest in science at an early age. She loved math in elementary school. She remembered doing fractions in grammar school as well. In addition, she reported that the social class background. She grew up in a working-class foster family with five siblings (three brothers and two sisters). She remembered that the family gathered for reunions in the South. There, they had fish fries and barbeques. Leaving the state for family reunions down South were considered family travel and vacations for Kayla.

Besides her family background, she recollected her childhood neighborhood being predominantly Black on the Westside of Central City. However in the 1990s, the Westside of Central City was 80% white and 20% minority (U.S. Census Bureau, 2000). The average family household size was four people. Less than 60% of men and women were married. In addition, over 70% of the population ages 16 or older were employed (U.S. Census Bureau, 2009). They also had a median family income of \$65,000. So it was understandable that less than 10 percent of families lived below the poverty level. Fewer than 75% of the population held a high school diploma and about 25% of the residents ages 25 and older earned a bachelor's degree as well.

Likewise, Kayla's foster parents graduated from high school. They also went to college, but never finished their degrees. Despite these educational challenges, Kayla's foster mother's granddaughter went to an HBCU down South. However, none of her family members completed a degree in math or science. Similar to Kayla's family's educational attainment, few of Kayla's

neighborhood peers went to college. Of the ones who attended college, the majority of them enrolled at community colleges or less selective four-year institutions.

Unlike many of the neighborhood peers, Kayla attended a private, predominantly white college preparatory high school with multiple advanced placement and honors classes to prepare her for college (National Center for Education Statistics, 2010). In 2009, Kayla entered Town University as a freshman interested in majoring in health science. By fall 2011, Kayla was a health science major transitioning into chemistry as her major at Town University. She enrolled in science classes, including biology and chemistry and a Calc II class. Outside of class, Kayla was a busy lady who worked as a residential advisor in a dorm at Town University. She also participated in organizations centered in chemistry and health.

Case 16: Rachelle

Rachelle was a talkative, assertive, and kind biracial woman. She identified as African American. She opened up in the second interview to discuss her experiences in K-12 schools and the passing of her mother in high school. Consider for example, she became interested in science in high school when she realized that the other subjects (e.g., history) were not interesting. Additionally, she described her family background. She identified as a part of the middle-class due to her parent's income. She also grew up as the only child. She disclosed that her mother died in high school. Later when her father remarried, she gained a stepbrother. She remembered family gatherings with her uncles and aunts as well. Family gatherings consisted of traveling to the West Coast and South for her birthday. She traveled to museums and malls in Central City.

Besides the family background, Rachelle provided a vivid description of her former neighborhoods. Rachelle was born in Central City. She recalled it being predominantly African American with few whites. She remembered living in a quiet neighborhood within a gated community. She also reported that the neighborhood changed to a not so good neighborhood.

Now her parents live in a suburb called Northern Heights. She described it as a place with less friendly people and predominantly white residents. However, she stated that her neighborhood was African American.

Consistent with Rachelle's description of Northern Heights, the U.S. Census Bureau (2009) reported that it was 75% white and 25% minority between 2005 and 2009. The average household size for families was three people. The marriage population was about 60% for men and women as well. Sixty-five percent of people ages 16 and older worked. So it was understandable that the median household family income was approximately \$90,000. Less than 5% of families lived in poverty as well. Additionally, approximately 95% of the population held a high school diploma and about 40% of the population earned a bachelor's degree.

Similar to Northern Heights' educational attainment, Rachelle's stepmother finished college with a bachelor's degree. Her father also completed an associate's degree and later obtained certification in construction. To add to that, the majority of her neighborhood peers became teenage parents.. So they did not obtain further education beyond the high school diploma. However, she reported that about 90% of her graduating high school class went to college. She went to a predominantly minority high school that offered advanced placement courses and STEM courses (National Center for Education Statistics, 2010).

In 2008, Rachelle entered Town University as a freshman interested in biology. As a senior in fall 2011, she took chemistry and biology classes. She also taught a service learning course. Outside of schoolwork, she held two jobs. In one position, she managed a team of students. At the other job she developed programs for freshman students. She was also a part of student organizations including an African American health club and a mentoring organization. In spring 2012, she plans to graduate from Town University with a bachelor's degree in biology.

Case 17: Lara

Lara was a soft-spoken yet assertive and helpful African American woman. She was always interested in math. At the tender age of eight, she began working on math problems with her brother who was two years older than her. In addition, she opened up to describe her experiences in predominantly Black schools in Central City. For instance, she spoke about the multiple African American female math instructors in primary school throughout high school. The exposure to these role models might have accounted for her interests and success in math in K-16 schools. Moreover, she spoke about living in a lower-middle class, single-parent family with her mother and brother. She also remembered family gatherings consisting of food, fellowship, and fun during birthdays and holidays including: the Fourth of July, Christmas, and Thanksgiving. Her family traveled to Jamaica, Australia, and Mexico as well. Some of the traveling was in part due to her brother and her karate tournaments

Equally as important was Lara's neighborhood context. She was born and raised in Central City. She described Central City as predominantly white with a few whites and Latinos. She recalled her neighborhood peers coming from low income families. She also remembered her peers participating in street life activities, which contributed to fewer of them graduating from even high school. Some of her neighborhood female peers became mothers as well.

Consistent with Lara's description of Central City, the U.S. Census Bureau (2000) reported that 80% of the population was white and 20% were minorities in the 1990s. The average family household size was three people. The marriage population consisted of 50% of men and women as well. In addition 65% of the population ages 16 and older held jobs (U.S. Census Bureau, 2009). The median family household income was less than \$50,000. More

importantly in Central City, approximately 80% of the population held a high school diploma and less than 35% earned a bachelor's degree as well.

Comparable with Central City's population, Lara's mother obtained a high school diploma. Her mother also earned a bachelors and a master's degree in social work (a social science field) from Town University. Her aunt obtained a degree in physical therapy as well. However, none of her family members earned degrees in math. She also recalled that few of her neighborhood peers attended college. The peers who enrolled in college took classes at community colleges. Unlike her peers, Lara's low-income, predominantly minority high school offered a few advanced placement and honors classes in English, math, social studies, and science (National Center for Education Statistics, 2010).

In 2009, Lara entered Town University as a math major. As a junior in Fall 2011, she remained a math major. She enrolled in classes in subjects, such as biology, ethnic studies health, and math. She also worked in the dorm to advocate for minorities and participated in student organizations. The student organizations included an African American health organization and a mentoring organization. She was also a part of a Diversity Leadership Program. By the end of the study, she was considering switching her major to chemistry. However in January 2012, she reported continuing to pursue a degree in math at Town University.

Concluding Summary

From this chapter it is clear that the family background, neighborhood, and school context influence the postsecondary experiences of African American women in hard science majors. Consider for example that the majority of African American women in hard science majors came from lower-middle class to middle class families (with two exceptions from working-class families). Whereas the majority of health science and social science peers were from working-class or lower middle -class families (with the exception of one from the middle

class). Equally as important was that mothers' educational attainment accounted for African American women being in hard science majors. For instance, in hard science majors the majority of African American women had mothers who held college degrees ranging from associates to masters degrees. The educational background of mothers might have accounted for these women remaining in hard science majors, due to their accumulation of academic capital¹⁸ and family capital.¹⁹ Additionally, the mothers of social science or health science majors held more high school diplomas than college degrees. Some of the mothers attended college for some period of time but dropped out. In a similar fashion, in hard science majors African American women's fathers earned more bachelors and advanced degrees than fathers whose daughters were in health science or social science majors.

Equally as important were the neighborhood and school contexts. For instance, the majority of the African American women in hard science majors lived in suburban areas. As a result, they might have been exposed to people in racially diverse suburban neighborhoods. This might have made these women have a smoother transition into Town University's environment in a predominantly white town. Additionally, their high schools might have prepared them for the science curriculum at Town University, due to the monetary resources invested in the schools for curriculum, instruction, and labs. However, the majority of African American women in health science or social science majors were only exposed to city life. This also meant that they were exposed to racially segregated neighborhoods and schools (some with fewer resources) unlike the typical atmosphere of Maytown. Therefore, challenges with science curriculum and

¹⁸ Academic capital refers to parents' aspirations for their children, parental involvement, and a child's intellectual ability, and academic achievement (Majoribanks, 1998)

¹⁹ According to Gofen (2009) "family capital attempts to capture all aspects of investment made by family for the benefit of the children's future" (p. 107). This includes: parental involvement in children's education; parents serving as facilitators of their education by investing in books, and encouraging kids to continue engaging in schools.

the culture of Town University might have accounted for additional stressors experienced by these African American women.

The aforesaid analysis of educational background of the participants' parents provides evidence of and academic capital that promoted the success of these African American women in college. However, when taking a closer look at the occupations and educational majors of the family members, one can see the challenges that these women might face when trying to pursue science majors as the "first person" or "one of the few" in their family at a PWI. The next chapter further explores the differences in African American women who remained in hard science majors and those who transitioned from hard science majors into health science or social science majors.

CHAPTER 5

FINDINGS ON AFRICAN AMERICAN WOMEN IN SCIENCE

This chapter reports the findings from this research study on the persistence of African American women in hard science majors. It examines the differences between African American women who remained in hard science majors and those who transferred from hard science majors to social science majors or health science majors. As stated in previous chapters, the main question that guides this research study is: Why do some African American women at a predominantly white institution persist in hard science majors while others depart from hard science majors? Recall the subsidiary questions that guided this research were:

- (1) Does forming a science identity influence the persistence of undergraduate African American women students in science majors?
- (2) Does the availability of resources impact the persistence of African American women in science majors?
- (3) Does cultural capital affect the persistence of African American women in science majors?
- (4) Do African American women who persist in science majors face challenges based on multiple identities (e.g. race, class, gender, and ethnicity)?
- (5) What types of strategies do African American women use to persist in science majors?

To answer the aforesaid research questions data (e.g., interviews, journals, and a demographic sheet) was used to compare and contrast the differences between African American women who remained or left hard science majors. In this chapter each research question is reported in separate sections in the form of themes derived from the data. The first section addresses theme 1: “persistence in hard science majors” which is the main research question. The next part

demonstrates how theme 2 “science identity formation of African American women” is answered by subsidiary question 1 centered on African American women’s science identity formation. To add to that, the following portion describes theme 3; it centers on “resources and persistence.” It explains the sources of support that African American women used in hard science majors given the availability of resources and it responds to subsidiary question 2. Following that is a discussion of African American women’s access to cultural capital. This section replies to subsidiary question 3 by reporting the findings from theme 4 “cultural capital and African American women.” Equally as important, theme 5 “challenges faced by African American women pursuing hard science majors” corresponds with subsidiary question 4. It explains the adversity that some African American women encountered in pursuit of undergraduate degrees in hard science majors at Town University. The final section addresses theme 6, which are “strategies used by African American women navigating hard science majors.” Following that part is a concluding summary.

Theme 1: Persistence in Hard Science Majors

The main research question asked about the differences in persistence of African American women in hard science majors compared to those who departed hard science majors. African American women’s persistence in hard science majors can be attributed to (1) individual interests, (2) school environment, (3) home environment, (4) science culture environment, and (5) commitment to major or careers. Each explanation is further explored in this section.

Individual Interests

Individual interests influenced the persistence of African American women in hard science majors. Consider for example all of the African American women in the study developed an interest in science or math in primary or secondary schools. The majority of African American women reported interests in science or math in primary schools. This is displayed by

the selection of narratives below from participants who answered a question about when they developed an interest in science or math.

I always loved math from the beginning. I wish that I had known about the physics and chemistry before. Math was always my favorite subject in grammar school... I am more of a critical thinker. Even now, I'd rather figure out a chemistry problem as opposed to memorizing stuff. I always liked the critical thinking of it. (Kayla, health science major)

I have always loved math until college. The furthest that I can go back to adding and actually doing problems in math. I was interested in that for some reason. It was easy. I was able to catch on. I was always quicker than my classmates. My teachers wanted me to move up to gifted programs. I have always been strong at math. For one of my classes...it was fourth grade, we had a little business. I signed up for that and we were basically selling candy before school started and after school. I always wanted to work at a register. (Patricia, business major)

I always had a huge passion for science. When I sat down, and said, I want to be a doctor. It would have been in my sixth grade curriculum. At that time, we had a lady come into our school during job fair day. She was an oncologist. At that time, my mother was also battling cancer. My father's mother had just died of a combination between ovarian cancer and diabetes. I was like wow that is what I wanna to do. When I got older, I started having my own medical issues and it was like sealed like no, this is what I wanna do. (Carmen, sociology major)

To add to that, a handful of participants cited being interested in math or science in high school.

This is reflected in the excerpts below.

Actually in high school. All throughout elementary school and grammar school, I never really had a preference. I just did it, because it was homework. In high school, I started realizing that I don't like history. I am really not too fond of English. Science kind of clicked. I was inquiring more about the body and things of that sort. So that branch of science kind of grasped me. (Rachelle, biology major)

It probably wasn't until high school. I liked my high school science class... It was just really the teachers were good. After sophomore year, it was like take chemistry or physics and physics did not sound as fun. So, I took chemistry. (Simone, engineering major)

By the time high school came around, even though I was generally good at everything still, I definitely was designated the math kid. I was in every math class... I was at the top or did the best on exams. But it still didn't stick out to me, really, yet, that that's my *calling*, until my senior year when I was doing math homework, and I was talking to my mom, and I was like, *this is just so much easier; this is just what I like to do*. I would prefer my math homework and my math classes to writing papers. And my mom was

like, *you can major in that. Did you know that?* And I was like, *no, I should do that.*
(Jennifer, math major)

From these narratives it is clear that early exposure to math and science might have resulted in their continuance in math or science in college. Hence, these findings are similar to previous research on the connection of African American women's early interests in math or science to later persistence in those hard science majors in college (Jordan, 2006). Additionally, some participants reported that teachers actually encouraged them to engage in science or math. This is shown in the narrative below.

I enjoyed physical science freshman year, because she was the one good science teacher that I had that knew the material and that could teach it to us and break it down so that we could understand it... Math, I want to say that I had a lot of good teachers. Math is kind of different, because it is individual based and you are trying to learn everything on your own. By me being able to catch onto the materials, I would be able to help other people out whenever we had time to work with people in class. I enjoyed being in my math classes. (Patricia, business major)

This quotation demonstrates the important role of teachers in African American women's engagement in math and/or science curriculum in high school. It also corroborates research on the impact of teacher support on African American women's engagement in math and science curriculum in primary and secondary schools (Jordan, 1999, 2006; Warren, 1998).

Furthermore, some African American women reported the primary and secondary school teachers being *cheerleaders, encouragers, and supporters*. This might be seen as *interpersonal caring*²⁰ which is comparable to instructors in the 1950s who taught Blacks in Southern schools prior to the *Brown v. Board of Education* decision in 1954 (see Siddle-Walker, 1993, 1996; Siddle-Walker & Tompkins, 2004). Recent literature confirmed that instructors scaffold

²⁰ The framework of interpersonal caring involves "the person who is caring is concerned about, and willing to attempt to meet, the physical, psychological, and academic needs of the individual for that person is caring" (Siddle-Walker & Tompkins, 2004, p. 79). The notion of caring is tied to the schooling of Blacks in the South. After the 1954 *Brown v. Board of Education* decision, Black teachers and principals exerted personal care to Black children by serving as counselors, encouragers, instillers of racial pride, and benefactors—by providing college funding and job contacts after high school (Siddle-Walker, 1993, 1996; Siddle-Walker & Tompkins, 2004).

students' interests in science through a caring and nurturing environment (Xu, Coats, & Davidson, 2012). This environment provides students with real-life applications of science concepts through hands-on engagement in science projects. Similar to previous research, in this study, African American women spoke about the importance of caring instructors in supporting their learning of math and science. This is shown in the excerpts below.

If you want to talk about a caring instructor, an all-around caring instructor, I had one, Mr. Collins... He took a serious interest in me... That did a lot for me at that time, because I was really messed up trying to be me in everything and do everything perfectly... You know nobody is perfect, especially with how I feel about math. That could never be reached. So, I was feeling like a failure in those areas. But he took the time to exaggerate the areas that I was good at. [He tried] to take my reading skills and bring it into math and he did not have to cause that was not his field of study. Nor was that section to teach, but he cared. And he was like, I want you in all honors classes when you go to high school. He cared. (Carmen, sociology major, former biology major)

I know in grade school, I would say we didn't do reading out of a textbook, we did a lot of hands-on projects. One time I think we made lamps out of pop cans. We had one project we did one year, and we made model rockets from scratch. Another year, I think it was my 8th grade year we actually learned how to make a bomb. (Celeste, sociology major, former business major)

If we did not understand something or were struggling, he actually went through it and made sure that he went over the material over and over to make sure that we got it and understood it to perfect it. He was hard on us. He made sure that we performed to the best of our abilities. I did not have the most confidence in the world. He would push me, again I was shy. So, he would want me to speak up and to articulate my ideas, thoughts, and opinions about things, which at one point I hated...He explained to [my mother] why he was doing stuff and telling her that I had so much potential. I should be able to share my ideas with the rest of the class and not just keep it to myself...He was thinking more on a college-level when he taught us. So, we actually went on a college tour to HBCUs in the South. (Patricia, business major)

The aforesaid section points to the important supportive role of teachers as motivators and encouragers to African American women to continue engaging in difficult curriculum in the K-12 schools.

However, in college when African American women faced adversity in science or math classrooms their interests and engagement in math or science waned. For instance, some health science majors and social science majors changed majors when they faced adversity in hard science classes. This is displayed in the following narratives.

I knew when I was sitting in the classes and I did not at all like the classes. It was not anything in me that enjoyed sitting in the classes. And that's when I knew at first, I didn't want to acknowledge it, because ... I've always said I wanted to be a doctor. I don't want to be seen as, *Oh, she's taking the easy way out*, or *She's going to be a failure*. So I didn't acknowledge it right away. Then I thought about it. I'm not happy doing this now, I'm not going to be happy doing it later, I'm not going to be happy in med school. And even though I would probably like being a doctor, the road to being it would be miserable for me, because I'm not liking the information. So I would say that was the end of my freshman year, beginning of sophomore year. And at the end of my first semester sophomore year, I think that's when I decided definitely no for med school, definitely no for biology. It's not me. (Crystal, health science major, former biology major)

I probably feel like I kind of want to, that's only because I kept failing the exams and I'm just like, is this really for me? Is this really what God wants me to do with my life? Is this a sign? At the same time it's like I want to be a doctor so I have to know this information so I'm going to stick it out. (Amber, health science major, former biology major)

The aforesaid narratives demonstrate the curricular challenges (e.g., course failure) faced by African American women. Few researchers (see Bradley, 1997; Gilmartin, Li, & Aschbacher, 2006; Hanson & Johnson, 2000; Jordan, 2006; Justin-Johnson, 2004; Warren, 1998) explained experiences of African American women's continuance or departure from hard science majors in college. In addition, Amber pointed to some difficulties learning from teachers in science classrooms at Town University. She stated:

Talk to me! Be excited about what you are talking about. Now there is no enthusiasm. He is a broken record. I do not know how you expect people to learn that way. We are not robots. We do not pick up on the monotone of your voice. If you are monotone, then you are putting people to sleep.

Hence, adversity in science classes due to curriculum or teaching styles at Town University resulted in some African American women departing from hard science majors. So, teachers

played significant roles in encouraging and supporting undergraduate African American women pursuing hard science majors through the delivery of the curriculum.

In contrast, African American women in hard science majors continued to be interested in pursuing their degrees in hard science majors in spite of the distress they encountered in hard science majors. Those hardships actually made some African American women begin to question future career paths as shown in the excerpts below.

So, my first semester here, I did not do so well. I wanted to change my major...I was thinking that I really don't have to major in biology to go to medical school. So, I was really contemplating changing my major. I thought about it some more, I slept on it...I am almost done. It is not that bad, as long as I graduate. That looks ten times better than graduating in something that is completely easier. And then of course after I get through the classes, I will still learn the materials. So, I didn't change it. I went through that for maybe about a week; thinking about changing. (Shannon, biology major)

I was tired of all of the basic classes; I just wanted to get out of the major. I rushed my classes and I took a lot of classes at the same time. I was off campus. I couldn't hang out like I used to. All that I did was study. I decided that all I could do was study. I was frustrated. I hated it. I actually went over and talked to the Architecture Department and I was getting ready to put my papers into transfer and my friend made me talk to one of her friends who was in architecture that graduated. He basically told me to stay. He does the same work and gets paid less. I am not doing that. (Simone, engineering major)

The above excerpts showed how in face of adversity that some African American women in hard science majors continued to pursue degrees, which might be connected to their career aspirations. This can be seen as *resiliency*. According to Walsh (1998), resilience is known “as the capacity to rebound from adversity strengthened and more resourceful” (p. 4). In this framework, Walsh (1998) observed that “qualities of resilience enable people to heal from painful wounds, take charge of their lives, and go on to live fully and love well” (p. 4). By applying the resiliency framework to African American families, Martin and Martin (1978) discussed how extended family members pulled together resources in order to survive in spite of obstacles. Hill (1997) also posits that “the cultural resilience of African American families headed by women is largely based on their strong achievement orientation and work ethic” (p.

111). They are also able to not only thrive, but survive “at different stages of their life cycle because they are part of extended-family support systems” (Hill, 1997, p. 111). Single-parent, Black mothers instilled education as a value and push for higher educational attainment in their children as well.

Additionally, for hard science majors career interests might have been due to self-motivation and self-confidence in the major or math and science curriculum. When asked what kept her in the biology major, Briana stated “*self-motivation*, I prayed a lot. Just like because I really didn’t know. That was one of the questions that I was asking God. Like am I supposed to not do this or is this like a perseverance test?” So, through perseverance in the classes African American women like Briana overcame obstacles in math and science classes (e.g., rigor, self-doubt). The perseverance test can be summed up in the words of Briana, when she says “To try again. Fall and then get up and try again and to come back next summer and take the same course again but with a different professor. It was much better, [I received a] B+ in the course.” Hence, by sticking with rigorous coursework some African American women remained in hard science majors. To sum up, individual interests account for some African American women’s persistence in hard science majors. In primary and secondary schools all African American women were interested in math or science. So they continued engaging in these subjects in college. However some African American women who faced adversity in college departed from hard science majors and declared majors in health science or social science.

School Environment

The school environment influenced the persistence of African American women in hard science majors as well. Similar to previous research studies (see Bradley, 1997; Gilmartin et al., 2006; McGee, 2009), high school course-taking patterns impacted the college-going behavior of undergraduate African American women. Additionally it affected the preparation of African

American women for hard science majors. However, some African American women were better prepared for hard science majors at Town University due to exposure to specific advanced and honors curriculum offered during high school. This finding varied among hard science, social science, and health science majors.

I would say biology definitely, that is probably because I took an AP course in Bio. Chemistry was a lot of general chem., when I came here, the chemistry program is very difficult. I don't want to say that it didn't, there was so much more taught at the university. I had a basic understanding of Chem when I came here. (Ashley, biology major).

I didn't take science classes here. I just didn't have to in college. I know some people who it did cater towards their major. People who were in my classes and they definitely felt prepared. But I didn't have – they didn't really test any of my knowledge...I definitely felt prepared when it came to math. (Jennifer, math major)

AP chemistry did. I did not take intro level chemistry here. I went straight to the General Chemistry. So, I ended up testing out of the introductory chemistry class. So that did a great deal, because I did not have to waste a semester redoing that. Anatomy and Physiology did. When I took Anatomy and Physiology part I last Fall, it was a lot of stuff that I remembered. [Anatomy and Physiology] part II was a different deal, it was a lot deeper. As far as part I, it definitely helped. I did not have to learn or relearn for the first time. It was pretty much review and moving onto other things. (Raven, health science major, former biology major)

From this section, the alignment of high school curriculum with college curriculum might have resulted in some African American women feeling confident in the introductory math and science courses at Town University. Hence, this might explain why some African American women initially persist in hard science majors at Town University. This finding is consistent with previous research suggesting that academic preparation influences the persistence of African American women in college as well (Malcom, 1993; McGee, 2009).

Equally as important, other African American women who came from schools in which they felt that even the advanced placement curriculum in math or science failed to prepare them for college-level math or science classes. When asked about high school math curriculum, Carmen reported taking the following classes: “Algebra, honors Algebra. Then I took honors

Pre-Calc and honors Calculus.” She was further probed to see if high school classes prepared her for math at the university. She replied “No.” Similarly, a former biology major Raven stated that “Biology. No. It was a horrible teacher.” Shannon reported the misalignment of high school science curriculum with college science classes. She stated:

I was signed up for AP biology my senior year...She [the school counselor] told me if you are a science major, they do not recommend that you use your AP credit, because when you use your AP credit that means that you do not have to take the class here. They know the college curriculum does not even compare to high school. So you need to take the class once you get here. Since they said that, I did not take the AP class, but it would have helped me so much had I taken it. So, I got a little bit of background in chemistry, and in biology, and in physics. It really is no comparison for what you really need to know once you get here.

The aforesaid text points to the important role of high school counselors in properly advising students for college-level science curriculum. Hence, if teachers, parents, or school counselors encourage African American women to pursue advanced placement and honors math and science classes then they might feel more comfortable engaging in these courses at the college-level. However, a caveat might be that some high schools’ science and math curriculum fails to align with the college-level rigor of a school like Town University. So some African American never had an equal opportunity for success in science or math curriculum at Town University, due to their previous exposure to math or science curriculum in high school. This resulted in some African American women taking fewer math or science courses at Town University. Other African American women might have transferred out of hard science majors into social science and health science majors due to difficulties with the curriculum.

To summarize, the school environment impacted the persistence of African American women in hard science majors. African American women who felt prepared from math or science through high school curriculum reported that they were prepared for college-level math and/or science. However, African American women who believed that their high school math or

science or math curriculum was misaligned with college-level math or science experienced the most difficulties in those subjects in college.

Home Environment

The home environment influenced the persistence of African American women in hard science majors as well. For instance, family educational background impacted the persistence of African American women in hard science majors. Consider for example that as seen in Chapter 4, mothers of hard science majors had the highest college attendance when compared to the educational background of health science and social science majors. Additionally, parental involvement in primary and secondary schools might have encouraged African American women to continue to pursue math and/or science throughout the educational pipeline.

I just remember I really liked the math class, and we had a problem of the week every week that I would do again with my dad. And I distinctly remember doing that.
(Jennifer, math major)

I've been to a Children's Museum of Science. We had a membership there. The water...was my favorite part of the Children's Museum probably because you got to play with water. It was great. But yeah, we went to all the museums and aquariums and science of all types. My dad used to take us fishing when we were little, so we had aquarium biology. So, my parents ,dad especially wanted to expose us to as much as he could. (Amber, health science major)

These quotations confirmed that parental involvement through socialization is important to encouraging African American girls to engage in science and math early on. Furthermore, this research showed that mothers in fact encouraged their African American daughters who faced adversity in hard science majors in college. The selected narratives below provided evidence that African American mothers encouraged their daughters to stick with their majors even when faced with adversity.

My mom. She called me recently and told me that she was really proud of me and it did not matter what I majored in or whatever. Sorry. [ON: tears rolled down her face]. She has just really been there for me. (Lara, math major).

My mom. I'm always calling home. Mommy I failed this test. She was like *change your study habits. Do the review.* She's my rock. (Danielle, health science major)

To add to that, a handful of fathers supported their daughters who faced adversity in the science major curriculum at Town University. This is summed up in the following narrative of Rachelle.

My dad. He really wants to see me succeed. He is always the one to say, *I cannot do it. It is too hard*, like daddy it is too hard is not good enough. If it is too hard, then [Daddy said] try harder. He has never been the one to pity me. Now that I am older, 'daddy my stomach hurts,' well get over it you are fine. I think not having the tender part of it, just having that hardcore male's point of view just pushed me to go through it.

Hence, the support of parents, both mothers and fathers results in the persistence of African American women in hard science majors. Parental support influences the continued engagement in science and math curriculum for African American women who transitioned into health science or social science majors as well. More importantly, parents served as the main *cheerleaders* of the African American women given that some lacked support of teachers that they previously had in the primary and secondary school environments. Furthermore, these findings complimented previous research that pointed to parental support influencing the persistence of African American women in hard science majors (Jordan, 2006; Warren, 1998).

In closing, the home environment impacted the persistence of African American women in hard science majors. Contrary to previous research (see Burke, 2007, Clewell, Anderson, & Thorpe, 1992; Hall, 2007) on the departure of women from STEM fields, African American women in this study who left hard science majors still had support from family members to continue pursuing degrees in health science or social science majors.

Science Culture Environment

The science culture environment affected the persistence of African American women in hard science majors. Consider for example that African American women who lacked *fit* in the culture of science at Town University were more likely to switch majors than those who felt

comfortable with the culture of science. This finding was similar to previous research on African American women who departed from hard science majors due to an ill-fit within the science culture (see Gilmartin et al., 2006). When asked about adversity in the science curriculum, Simone and Rachelle responded in the excerpts below:

Every Thursday when I am doing homework. I would say the worst time, I had moved off campus my junior year. I moved kind of far off campus. I was tired of engineering...(Simone, engineering major)

When it got hard. I think the first semester freshman year I told you about the classes that I had. It was just horrible...Sophomore year it was so hard my classes were kicking my butt. I was trying to see if it was for me. I did not feel as though I was putting forth the effort. I would study last minute reviewing my notes. I wasn't trying. (Rachelle, biology major)

Both Simone and Rachelle found support systems. They learned to how to conquer these challenges and successfully navigate through the science communities. By overcoming adversity through resilience, they remained in hard science majors at Town University.

To conclude, the science environment influenced the persistence of African American women in hard science majors. Consistent with literature (see Gilmartin et al., 2006) on African American women who felt comfortable in the culture of science were more likely to persist in hard science majors than those who were uncomfortable. Discomfort resulted in less sense of belonging and an ill-fit in science communities and thus departure from hard science majors.

Commitment to Major/Career

Commitment to major and/or careers also impacted the persistence of African American women in hard science majors. African American women who were committed to careers that needed a background in math or science classes were more likely to remain in hard science majors in spite of challenges. When asked the question of what made you stick with the math curriculum, Lara responded:

In math my successes have pretty much been sticking with it through the bumps, just working hard. Doing what I have to do even if I get that C or if I get that D. I feel like sticking with something that is hard has made me stronger instead of giving up and doing something else. My minor in chemistry that stuff just comes easier. I get it grade wise that would be my success.

When further probed about career support, she stated: “My mom. Initially as far as being a doctor, it was my pediatrician when I was like seven or eight. As far as encouragement, my mom she has been a major support of my career goals.” Similarly, Patricia discussed her early career aspirations and supporters. She said “going back to my younger days I wanted to be a teacher, if not a teacher a business woman. Those were my exact words.” In college, Patricia faced adversity while pursuing the business degree at Town University. Below is Patricia’s narrative about adversity in the business major. She says:

I was working and I was doing all these meetings and stuff and *I’m like oh my God*. I can’t do this anymore. This is too much and I was either ready to take a semester off or I was contemplating going into education, because something in me really wants to be an education major. I want to be an elementary school teacher, but then again something keeps [me] going.

When asked who supported her career goals, Patricia pointed out that “again, that was the same people like my mother and she stands behind me and then, family, my mentors....” The above narratives suggest the importance of parental support and commitment to hard science majors and careers in hard sciences. These findings also confirmed previous literature that connects continuance in hard science to career aspirations (see Gilmartin et al., 2006; Jordan, 2006).

Equally as important, some African American women who were interested in medical sciences also had a passion for continuing to engage in math and science curriculum, because of their career aspirations as doctors. When asked about early career aspirations, Amber reported “first I wanted to be a chef and then a pediatrician, a doctor, and then it got more specific to children.” As an adult, she faced difficulties as a biology major at Town University. During that time she consulted her parents and others from her hometown. She further explained that those

challenges with the science curriculum resulted in her having thoughts about departing from Town University as shown in the selected narrative below.

Yeah, that would have been the time. you're doing all this work and it's not paying off and it's like, why am I here, but that's the only time I've ever felt like I don't want to be in school, but I love school. It is just this school.

To remove those feelings of doubt and inadequacy in college, her parents and other supporters encouraged her to stick with college, biology, and the health career. She stated:

My mom even told me if I don't go to medical school right away you're going to get a CNA license. They're pushing me to make sure that I can become what I wanted to become and be able to change the world in the way I want to. They've given me many avenues...So my parents are like my main enforcers so that even though you *fail you still can get back up*. It's not the failure that produces you, it's how you react to it. If you react to failures it will make you successful, so this is how I'm reacting, and I'm attacking it, so I feel that I will be coming out on top in the end.

This quote contradicts previous research which states that women who depart from hard science majors lack parental support (see Burke, 2007; Clewell, Anderson, & Thorpe, 1992; Hall, 2007)

In contrast, Raven who aspires to be a physician was not in fact challenged by the curriculum like Amber. Her main issue was the structure of the biology program. She states:

Again that has been something that I wanted to do for a long time. I did not feel the need to switch again it wasn't something that was stressing me out. Oh I don't feel like I can do this. I knew that I could do it. I just left the science major, because I felt that it wasn't giving me enough. As far as quitting that was not an option for me.

Raven's passion for science accounted for her continuance in taking upper level biology classes. She cited career and academic support from "family, friends, advisors, teachers, mentors." These narratives also pointed to the importance of support to encourage African American women to continue pursuing majors and/or career goals in spite of adversity in the science culture environment.

In contrast, African American women in social sciences whose career goals changed were less committed to hard science majors. This is shown in the narrative of Regina who had an early interest in becoming a businesswoman.

I thought that I would do accounting. I liked the cash register. I had a couple of cash registers growing up. I really like to punch those buttons. Accounting seemed like the area for me...I knew that I would have to take more of it [math]...Thinking about accounting their lifestyle is more sedentary, cubicle like and I just didn't want that.

Based on this section it is clear that commitment to hard science majors and/or engaging in advanced science or math courses is connected to career goals. So, African American women who continued in hard science majors were committed to engaging in the major for career related purposes. The same finding was true for African American women in health science majors who were interested in careers in health fields. Furthermore, the above findings corroborated research on career aspirations to engagement in hard science majors in college (Gilmartin et al., 2006). These findings added to literature suggesting that African American women who depart from hard science majors continued to engage in the curriculum due to career interests and/or bachelor's degree attainment with a major in health science or social science. Thus, as shown in previous research (see Becker, 1960; Locke, Latham, & Erez, 1988; Brickhouse, Lowery, & Schultz, 2000), commitment served as an explanation for why African American women remain in hard science majors or continued to engage in health science or social science majors. In conclusion, from this section it is clear that the persistence of African American women is due to individual interests, school environment (e.g., academic preparation), home environment (e.g., parental support), comfort in the science culture environment, and commitment to the major and/or career goals.

Theme 2: Science Identity Formation of African American Women in Science

This section reports the findings of subsidiary question 1. It focused on the formation of science identities of African American women who persisted in hard science majors when compared to those who did not persist in hard science majors. Forming partial science identities accounted for some African American women's persistence in hard science majors. Following are the findings on science identity formation. They are based on science identity formation conceptual framework of Carlone and Johnson, which includes competence, performance, and recognition.

Intellectual Competence

Similar to the research literature on intellectual competence²¹ (see Carlone & Johnson, 2007), all participants had intellectual competence as seen by their grades in science courses in primary and secondary schools. When asked about performance in science and math classes in elementary, middle, and high school, the majority of the African American women (regardless of major) responded that they obtained solid grades (e.g., A's and B's). A handful of participants obtained C's in math and/or science in high school. African American women reported performing average or above average in primary and secondary schooling, and college preparatory exams (e.g. ACT, SAT).

However, the majority of African American women's intellectual competence shifted in college, because of the academic rigor of the science and math curriculum at Town University. Consider for example, a math major Lara made A's in math and science in high school. When asked about her performance in math, she reported "I would say I'm average. I do okay, so...like a C." Yet she excelled in science. She continued to point out her performance. "I'd say

²¹ Recall that intellectual competence "involves using the mind's skills to comprehend, reflect, analyze, synthesize, and interpret" (Chickering & Reisser, 1993, p. 53).

above average. I say that I'm usually getting A's and B's, maybe a few B's in my science class and stuff. I'd probably say above average." This suggests that she might feel more confident in science than math at Town University.

In much the same way, a sociology major Regina felt less confident in her science and math abilities in high school. She described herself as an average student who made B's in science and B's and a few C's in math. In college, she also felt average in terms of performance in College Algebra. When asked to further discuss academic performance, Regina explained "I think that I had a B in that class. I thought that I did pretty good. Those exams were not in my favor, but then again, most exams aren't. Just average." Her difficulties in math and science explained why she used multiple resources. She says: "I have to struggle through, attend office hours."

This section points to the distress that some African American women faced early on in math or science classes, which made them question their intellectual competence in these subjects. Curricular challenges might have affected some African American women's academic confidence, which in turn affected their intellectual competence as well. Thus, some African American women who were unable to overcome the academic difficulties in college level math or science classes transferred into feasible majors to obtain a degree from Town University.

On the contrary, other African American women students who departed from hard science majors continued to perform at the same level of peers in hard science majors in math and/or science at the Town University. Consider for example Raven who made A's in high school math and B's in college-level math. She also disclosed the science grades in the excerpt below.

For biology, I've never got anything lower than a B. For Anatomy and Physiology, that was Genetics... I actually did get a B in that class. So for biology I've never got lower

than a B. Evolution and Organisms, I did get a C in that class. For chemistry, I have never gotten lower than a B, besides in Orgo Lab, I did get a C+ in that class. For Physics, I don't know if it's because I didn't take it here, but I've gotten A's in both of my Chemistry classes.

This section showed how the differences in classroom structure influenced students' performance in science and math college classes.

Equally as important, when taking the introductory science classes at Town University, the majority of African American women recalled there being more African American students and fewer African American students in the advanced level courses. A biology major, Ashley described the weed-out process in the introductory level science and math classes. She pointed out: "I know in math and chemistry that is absolutely the process cause they absolutely designed those exams for people to fail them and they tell us that in the beginning." Similarly a health science major, Raven acknowledged the weed-out process. She says "so usually in General Chemistry I, they start weeding people out, and people started saying, *Well, maybe this just isn't for me.* So as soon as you get up, you realize how many people have dropped off from when you were in General Chemistry I and Evolution and Organisms, Molecules and Cells." She continued to disclose the numbers of African Americans in the hard science classes with the following statement. "So I will take General Chem I. It would probably be like 400 of us. Maybe about 40 or 50 would be Black. Now, in my Biochemistry class, it's about the same amount. It's probably ten of us." To further examine the weed out process, the next section takes a closer look at the case of Carmen who switched from biology to sociology.

At Town University, Carmen in particular vividly described the weed-out process that she faced in some hard science classes. She states:

It was a biology class and I had a BioChem class. Yeah, I failed those. Just those two. It was so crazy, I had those two that I did horrible on. Then I had three other classes that I got two B's and an A in. So, it was like night and day. Then, someone was like they are

weed-out classes... So, I took them again. I don't know to this day. I am gonna say, I don't know if it was Town University or the situation. Last summer, I took the classes over at Town Community College and they are classes that transfer over. The guy that teaches them also teaches here. I got A's in them. So, I really don't know if it was the situation or if it was the school or what was going on. I am just glad that is over. Cause my first year sucked. I was crying every day.

This portion points to the weed-out process involving retaking classes, self-doubt, and a loss of academic confidence. So, in hard science majors the weed-out process might in fact be designed to fail students and thus they have to take courses more than once to succeed. In essence it might be a process that in order to *succeed* that you might have to *fail* first. Thus, the weed-out process explained why some African American women transferred from hard science majors to social science or health science majors.

Despite having academic difficulties in the introductory level math and/or science classes, African American women who persevered in hard science majors made higher grades in the more specialized science and/or math classes. In addition to curriculum challenges, some African American women who were unable to persist in science or math in college encountered barriers building relationships with instructors and/or peers. To add to the discussion on competence, the next section focuses on interpersonal competence²².

Interpersonal Competence

Interpersonal competence affected the persistence of African American women in hard science majors in K-16 settings. Consider for example that the majority of African American women held solid working relationships with instructors and peers in K-12 settings. This pointed to their development of interpersonal competence in the science community in primary and secondary schooling. In elementary school, Simone stated "I worked with whoever they put me in the group with. If I got to pick, then it was usually my friends." Similarly, in middle school

²² Recall that interpersonal competence is "a person's ability to communicate and work together with others (Chickering & Reisser, 1993).

Regina pointed out “we had just come from elementary school and we kinda grew up around each other, we were familiar enough with each other and maybe laugh and maybe get into a little trouble inside of class.”

Additionally, there were a few cases where the participants had challenges with instructors in these subjects. This might have accounted for their lowered academic performance in primary and/or secondary schooling. Biology major, Shannon says, “my relationship with that instructor was not that good for physics.” When probed a bit more about this relationship she pointed out that, “people had mixed feelings about Obama. He was one of those people who did not like him. He would say stuff like, just low-key racial things.” She later stated “I do feel like he made the class easy. So, I got good grades. I do not know why I got a C the first semester. I cannot remember, but I did not do poorly.” This quote points to the lowered performance of students in the classroom due to teachers’ attitudes and perceptions in classrooms. Hence, teachers might shape students’ learning and engagement in classrooms as well.

In contrast to primary and secondary schools, college was the timeframe when the participants’ relationships with peers and instructors shifted in the math and science classrooms. Since the lecture classes at Town University were unsuccessful in facilitating an atmosphere for bonding with instructors, biology majors Briana, Shannon, Ashley, and Rachelle built relationships with the instructors and/or teaching assistants during office hours. This environment allowed them to participate by interacting with the instructor or teaching assistant and other peers while simultaneously obtaining assistance on the homework assignments in a small group setting

Other African American women met with instructors in office hours felt that the environment failed to give them a solid grasp of the course materials. Consider for example the cases of Crystal and Amber who struggled in science classes at Town University.

I took Molecules and Cells. I was in shock. I did not expect it to be that hard. I go to the exam and I was like what is this? My study habits had not fully developed either. The second time that I took it, I went to tutoring. I went to the TU Resource Center, I went to office hours. I studied weeks and a week before the exam and I still came out with an F on the exam. It is like I am letting this go. It was not required. (Crystal, health science major, former biology major)

It was like office hours for teachers and staff and I did try to go to those. Sometimes when you go to office hours sometimes you feel intimidated by the teachers to ask a question. Like the way they talk to you... I don't know but Mr. Matthews [Professor of Molecules and Cells I] in his office hours and discussion was pretty decent though. He did review for genetics for the old people. They are pretty old. They are cool but they are old. And outside of class they are picky. It was funny because I am a *dumb Black girl*. I don't know but he was always like, well, you are still here. Did you think I was going to drop the class? (Amber, health science major, former biology major)

From these excerpts the structure of the biology classes coupled with the teaching and learning explained why some African American women transferred from biology to health science majors.

African American women in hard science, social science, and health science majors encountered challenges working with peers in science or math classes at Town University as well. Celeste remembered taking math and science classes structured with large lectures. She described the experience as *isolating*, because she did not have friends in the class. She stated: "I guess the only bad part would be that you can't ask nobody a question. I have experiences where I asked people like how to do something and they either don't know or just don't want to help people."

Ashley discussed her adversity in a physics class at Town University as well. When working on a group work in a Physics class, she says:

I was the only Black student in class, which I am used to, but in this group, I was the only female. I was the *only Black person, Black female*. There were three white guys and a lot of times, I definitely couldn't get a word in or if I had an idea about something it would be wrong, at least they thought that it was wrong, even though it was probably right. So, I could definitely tell there was something, definitely some discrepancies in the way that we're able to interact.

Similarly a health science major, Kayla described difficulties working with peers in study groups for physics, biology, and chemistry class. She states:

Usually there's not a lot of minorities in those classes, and you have to invite yourself to the groups or ask questions, because they won't come to you. Even in group work, I can tell there's a kind of dynamic to it. You still have to prove your presence, I guess... At first it was kind of annoying, just because *we all don't understand this*. I don't see why everybody's not talking to each other, and, like, talking at me, kind of. I just got used to it now. And if you make that presence known in the beginning, I feel like it's easier when it goes forward as the semester progresses

In spite of those challenges working with peers some health science majors and hard science majors built relationships with others in their majors. This enabled them to have conversations with advocates, including: peers, instructors, or their advisors. However, some social science majors had fewer social contacts to rely on when they encountered adversity with peers. To sum up, developing intellectual and interpersonal competence (via science identity formation) explained why some African American women remained or departed hard science majors.

Performance

Performance²³ also resulted in the outcome of African American women's persistence in hard science majors. Similar to previous research (see Carlone & Johnson, 2007; Jordan, 2006; Warren, 1998), African American women in this multiple case study showed an interest in science at an early age, due to participation in science activities inside or outside of the home.

When asked about early science memories, Carmen responded:

²³ According to Carlone and Johnson (2007) performance in science involves engaging in projects utilizing scientific methods and conversing about scientific methods using scientific language.

I have always enjoyed science. I hated math. I still hate it with a passion that burns deep in the lower parts of my soul. But I bear through it. As far as chemistry and biology, I have always been very interested. For the longest, I had a leaf collection, where I classified all of the different types of leafs and the trees that they came from. I stopped doing that probably around sixth grade.

From this narrative, we can visualize Carmen's ongoing struggles with math. Despite those challenges she continued to engage in chemistry in college, which focuses on math-related problems. Similarly, other African American women who departed from the hard science majors and transitioned into social science and/or health science majors had a stronger interest in math or science in primary schooling throughout secondary schooling, due to their academic performance in those classes.

African American women in health science or hard science majors showed an early interest in math or science as well. Consider the class experiments by Raven and Shannon below.

I was in fourth grade. I went to a private school up to fourth grade and we had to do a science project. I hadn't done one before. I want to say that I just transferred there. We ended up doing it wrong. Me and my mom did a project on the heart. So explaining the heart and how it worked. That was actually my first memory and partially the reason why I wanted to be a cardiologist. So, it was really intriguing even at nine years-old. (Raven, health major, former biology major)

When asked about a science fair example, Shannon responds "I was selected to go to a regional science fair, but I did not win there. So, I was really proud of that." She went into further details about the science project in the following statement:

I picked which soaps; I do not think that I knew exactly what I was doing when I designed it. I picked different bars of soap. I was seeing which ones had the highest levels of acid in it by using PH strips. I guess that I was picked for that, because it was different from what most students did. It really was not an accurate experiment. I was trying to see which one was healthier for your skin. (Shannon, biology major)

Thus, this section provided evidence that some African American women felt successful about their knowledge of scientific concepts as shown through these experiments. These early

experiences might have encouraged them to further actively engage in science in secondary schools and even college.

However, if measuring performance in science is based solely on Western standards of performance in terms of the scientific language and methods (see Carlone & Johnson, 2007; Lee & Lukyx, 2006), then some African American girls might have limited exposure to those scientific techniques in K-12 settings. The reason for the absence of scientific experiences might be due to fewer resources and/or exposure to scientific related activities. By expanding the definition of performance to include participation in science related activities and active participation in classes, this research study showed that African American women actively participated in science and math classes in primary and secondary schools due to voluntarily or forced participation.

For instance, in some primary and secondary school teachers encouraged active participation. This pedagogy encouraged African American girls to actively participate in math and science classes by asking or answering questions to demonstrate their knowledge of science and math concepts to their peers. In math, Ashley says, “if I did not understand something...I would ask questions to make sure that I understood something or if I just wanted to know more about a subject in general.” When asked, why did you participate in science? Ashley responded “I liked when people said, *dang Ashley, you are so smart*. I am not as smart as you. I cannot help it. I was a show off when I was really young.” Similarly, Shannon stated in elementary school math and science, “if I knew an answer, I was always eager to show the teacher that I knew an answer. I was always pretty good in math and science.” Similarly, Patricia explained her class participation in middle school math in the excerpt below.

Again, because I understood the materials; it was interesting. Sometimes you would have to go to the board and do stuff. We would have to do homework assignments and come in

and go over them. She would have us go to the board and write the problems down and teach the class how you got the answer, which was something that I liked doing.

In brief, this section demonstrated the importance of instructors encouraging active participation of students inside the science classrooms, which helps students with different learning styles better understand concepts discussed in class.

Unlike the aforesaid classrooms, other math and science instructors in primary and secondary schools discouraged African American girls from participating in math or science classes, due to the penal system. Celeste reflects on her middle school math and science instructors, “the math teachers, I liked them more and my science teachers, I did not, because they did not like me talking so much.” This quote pointed to the fact that students can be turned off of the classroom due to the actions of instructors. When asked about math participation level in elementary school, Shannon responded, “In seventh grade, she would get upset with us when we would ask questions or questioned why she did something. I became less comfortable with asking her questions.” This narrative suggested that instructor can impede the learning of students by discouraging participation in classrooms.

Similar to some math and science classrooms in primary and secondary schools, college math and science classroom gave African American women fewer opportunities to participate in classes at Town University. The culture of science (e.g., pedagogy, exam assessment, interpersonal relationships) environment at Town University accounted for some African American women leaving hard science majors and transitioning into social science or health science majors.

The rigor of the introductory classes at Town University resulted in some African American women regardless of major status (e.g., hard science, social science, health science) taking introductory math classes and/or general education science and/or math courses at

community colleges. In this environment they felt comfortable participating in smaller classrooms (similar to high school), yet they had limited interactions with peers. For example, when asked to explain a community college classroom Regina said, “it was a fairly open with the peers and professors. They seemed to be willing to accommodate, willing to help. I do not have a bad experience.” Shannon also participated in smaller classes, namely Calculus at a community college. She reported having a good experience in Calculus in which she participated more. “He did have a couple of times when he would have students come up and write their solutions to certain problems.”

To sum up, performance (via science identity formation) is tied to African American women’s persistence in hard science majors. While all students performed and participated in K-12 classrooms, some African American women faced difficulties in college-level math and science classrooms. Thus, some African American women took introductory level math or science classes at community colleges. Other African American women departed from hard science majors due to the structure of math or science classes at Town University.

Recognition

Finally, recognition²⁴ as a member of the science community might have resulted in some African American women’s persistence in hard science majors. Half of the participants recognized themselves as researchers including: Ashley, Carmen, Amber, Patricia, Raven, Simone, Kayla, and Lara. These participants were involved in research projects with professors or conducted research on their own. For instance, when Carmen was a student at an HBCU she conducted research on breast cancer under professors. So it was understandable that she identified as a researcher. However, Amber never worked on research projects under professors.

²⁴ Recall that recognition for science identity formation meant people identified as scientists (Carlone & Johnson, 2007). Others in the science community viewed them as scientists as well.

She engaged in independent research on the contributions of African American scientists. When asked about the contributions of African American women to science, Amber stated: “they have had a lot of contributions to science. A lot of home remedies, but most people don’t know about those.”

Despite the major status (e.g., hard science, health science, social science) of the African American women in science majors, the half of the respondents did not see themselves as researchers due to limited or no research experience. This is reflected in the following example of Briana. She worked in a research lab, but she still lacked a science identity as a scientist or a researcher. Briana reported: “you are an undergrad. It does not matter about ethnicity or gender, if you are not a grad student, you don’t matter.” To counter the notion that undergraduate students cannot be researchers, when asked about who recognizes you as a researcher, a graduating senior, Ashley said:

Probably the people in the lab who I work with. The professor does. She has good things to say about me. The grad student that I have been working with and yeah, mainly those two. Although, I am pretty sure that everybody else has this common recognition, everybody’s level within the lab.

Unlike Briana the fact that others in the lab recognized Ashley as a researcher might have resulted in her taking ownership of the researcher identity. This in turn might have sparked her interest in honing in research skills by writing a senior thesis and entering a doctoral program in the fall 2011 as well.

Similar to the findings on identification with researchers, the majority of African American women did not see themselves as scientists or mathematicians. Six participants reported that others viewed them as scientists (Shannon, Carmen, Ashley, Amber, Kayla, Lara). Some of respondents saw themselves as scientists, because of their major, research experiences; others identified them as scientists like professors or lab partners. Additionally one woman

viewed herself as an engineer (Simone) and five African American women identified as mathematicians (Jennifer, Amber, Patricia, Crystal, Lara).

For instance, Jennifer classified herself as a mathematician, which was not surprising because she pursued a math degree at Town University. Others saw Jennifer and Amber as mathematicians due to their school performance and ability to crunch numbers and answer questions about math problems. Identification with scientists, mathematicians, or researchers is due hands-on experiences in math, science, or research. These findings confirmed previous literature on science identity formation (see Carlone & Johnson, 2007). However, the denial of identities as researchers, scientists, or mathematicians might be due to not earning the degree yet or working in careers in math or science.

To conclude, from this section, science identity formation (e.g., forming partial science identities) explains why some African American women persist in hard science majors due to competence and performance. Additional research is needed to tease out how others African American women recognize them as scientists, mathematicians, and researchers and their own recognition as well.

Theme 3: Resources and Persistence

This portion of chapter 5 addresses subsidiary question two, which examines the availability of resources on the persistence of African American women in hard science majors. The main finding was that school resources accounted for the persistence of African American women in hard science majors. This section begins by discussing the availability of resources from middle school to college for African American women. Following that is a discussion of human resources that African American women relied on to persist in hard science majors in college.

Middle and High School Resources

The availability of resources varied for African American women. Consistent across all majors was access to resources in middle school and high school. Resources in middle school were more in the form of laboratory equipment whereas resources in high school included humans, books, and laboratory resources. Consider for example that beginning in middle school, some African American women conducted experiments as individuals or in groups. The materials in the labs ranged from Bunsen burners, to chemicals, and even dead animals. These hands-on experiences inside labs made science fun for African American women. The interactive learning components might have encouraged them to continue in the science and/or math educational pipeline in high school as well.

For instance, when asked about science middle school activities, Shannon responded “every other day, we were in the lab doing some type of activity. Other than that, it would just be independent studies. Pretty much, he would teach a lesson and we would do a worksheet.” Similarly, Amber further elaborated on the laboratory experiments conducted by teams in middle school science classes. She explained the vinegar and baking soda experiment. She said “I don't know the correct terminology for it, but they do mix, and the air bubbles go in the air.” In high school, Celeste also enjoyed team high school laboratory experiments. She stated “I liked the experiments because, again, I like to see stuff *blow up or burn up*. I especially liked when we mixed the chemicals together and they changed colors.” These findings are consistent with previous research that suggests that hands-on experiences impacts the persistence of African American women in hard science majors (Jordan, 1999).

To add to that, the availability of laboratory resources accounted for African American women's persistence in hard science majors, All African American women in the study were

exposed laboratory experiments in high school. The majority of participants had access to books and materials in high school. A handful of participants reported having limited books and materials due to their high school being low-income. Equally as important is that African American women relied on humans as resources in high school. These resources included teachers, parents, and peers. Teachers showed up as the most common resource for tutoring in math and science, followed by peer study groups and parents.

Half of the hard science majors learned to succeed in high school science and math classes through trial and error. They had few resources at school or even teachers to inform them of strategies to be successful in high school. When asked about who informed you about strategies to be successful in high school, Briana responded “No one. It was just something that I picked up on. I have good study habits. So, I will probably do well in the course.” Learning to succeed in face of obstacles was in fact the essence of resiliency. There were a few exceptions to the rule as in the cases of Patricia, Rachelle, Jennifer, and Shannon who learned from teachers or parents as well. For example, Jennifer relied heavily on her parents to teach her study skills and organizational skills. She explained that “...I have a test coming up and I was worried about running out of time and my dad might say look, do the easy ones first, because those will go fast and then do your hard ones...”

Moreover, in health science or social science majors, African American women relied on teachers or themselves to be successful in high school. For math, Crystal learned to be successful from an instructor. She pointed out “it was do your best...You have to work hard for what you want. Some of us were breezing through in high school, because it was not the most challenging high school. He challenged us.” On the contrary, when asked the same question Raven stated:

No one. It was kind of one of those things you learn along the way...I learned how to study. I learned what strategies worked for me..., if I have a lot of pages to read then I have to take notes at the same time for me to remember it. Then I work better with my hands when I am actually doing it, then I can remember it better.

This excerpt confirmed some African American women taught themselves how to succeed in math or science curriculum while others learned through trial and error.

In contrast, in social science and health science majors African American women learned to be successful in high school math or science from teachers or parents. When asked about people who informed her of high school success strategies, Regina admitted:

It would be my college prep teacher. That was like our class that we learned how to write business letters; learned how to type without looking at the keys. We just learned how to use a lot of basic computer programs and send proper emails.

Similarly, when asked about who taught you strategies to be successful in high school, Carmen pointed out “nobody really taught me skills to be successful, but I had a teacher who kinda forced success on me. Get up do your homework; make sure that you understand it.” She later stated that her parents taught her study skills as well.

The differences in availability of high school resources might have resulted in some African American women in health sciences or social sciences needing more resources to navigate through Town University in hard science majors. On the other hand, some African American women in hard science majors might have been used to relying on fewer teachers as resources thus they might have needed fewer resources at least in the beginning of college. They might have been comfortable relying on themselves and working through difficult curriculum through trial and error as well.

College Resources

Resources also differed for African American women in hard science majors, health science, and social science majors. Similar to high school, African American women were

exposed to laboratory resources using a plethora of equipment and materials to conduct experiments in a team based environment. However in college, some African American women faced hardships in the science and math curriculum at Town University. One of the greatest challenges that African American women students faced was *being the only one* in upper level science or math classes. This experience is described below.

At first...I don't want to say intimidating, but it's uncomfortable to just be the *only one* there. And then, I don't know, because you always want to surround yourself with people that you relate to, so. Yeah, I'm often to myself. But freshman year, it was kind of different, because it's like, "*Okay, I'm the only one,*" in every single class. But then after a while, I just got used to it. (Patricia, business major)

I guess it feels okay. I mean it's not like an amazing experience, but I'm fine with it...I don't really have a problem with going to the university, because I know a lot of my friends or a lot of the Black people that I know...they don't like or are not good at math. So I mean this wasn't something that I wasn't expecting is not to have many or Blacks in my math class. (Lara, math major)

These excerpts demonstrated the isolation experienced by African American women and how they coped with that barrier. To add to that, African American women who remained in the hard science majors overcame obstacles (e.g. limited lab experiences, competence, and isolation) by utilizing resources as well. These included: going to office hours, tutoring, and working with a diverse group of peers. For instance, Shannon is a second-generation college student, but she still encountered difficulties maneuvering through Town University, due to limited study skills. This might be attributed to her social class status. She learned how to study the science curriculum at Town University through trial and error. She explained: "when I first came here, I did not know how to study... I had to learn to come home each day, review materials; keep up with assignments and things like that... Just myself and learning from my bad mistakes." She also learned about office hours in college. Once she learned about the resources available on campus, she not only used them, but attributed them to her academic success. She stated: "tutoring was suggested. Well my best friend, she started going to tutoring at the Town University (TU)

Resource Center. She said it was helpful. So the next semester, I started going to tutoring for the classes that I anticipated being really hard. It was helpful.” From this narrative it is clear that availability of resources leads to persistence in hard science majors.

Additionally, the majority of African American women who stuck with hard science majors had larger support systems from family and friends, to mentors, advisors, and/or instructors. For instance they drew on academic advisors, professors, peers, parents, and employers to learn about being successful in college. Peer support, prayer, friends, family, and self-motivation have encouraged these women to remain in hard science majors. When asked about how she learned about being successful in science majors, Ashley responded:

I think mainly my professor and grad student that I have been working with in lab...my professor has already been successful, so she is always helping me out, teaching me...Collectively, all of the professors...they always throw out little tips and whatnot.

This quote suggested the importance of instructors facilitating the retention of African American women through support. It also corroborated previous research on African American women’s instructors who provided support as they pursued degrees in hard science majors (Henrion, 1997; Jordan, 1999, 2006; Warren, 1998).

Moreover, some African American women in hard science majors learned to work with peers who were different from them using their interpersonal talents as well. Simone describes her adversity in a Physics class working on a group project at Town University.

I’ve had a few classes where I was working with somebody that was Asian, and they didn’t want to do the writing, because they said that their writing skills weren’t good. But they were fine. They had good writing skills. But they tried to use it as an excuse. I was saying earlier in my engineering career, ... it was a little bit more difficult to find groups to work with in classes, so I had to make sure I was there that day.

This section provides evidence that difficulty in building relationships with peers affects the overall classroom experiences of hard science majors, especially in science labs. In spite of those challenges, some hard science majors built relationships with others in their majors, which

enabled them to have conversations or at least have an advocate on their side whether it was a peer, instructor, or advisor.

Another source of peer support was the buddy system. It was commonly utilized by African American women who persisted in hard science majors. The peers that these women associated with were not homogenous in terms of race or gender. They relied on peers who were male or female, African American, white, Asian, and Indian amongst other peers to successfully pass upper level courses in math or science classes at Town University. In the narrative below, Jennifer described the buddy system that she utilized in math classes at Town University. She recalled:

The first day, I found a buddy and me and this person check the homework together, studied for the test together, almost every math because I have so many numbers and e-mails of people that are my math best friends and then I met a few more this semester, but I can't name a class where that didn't happen. It's like I do that every year.

Unlike the hard science majors, some of the African American women who transferred to social science or health science majors utilized office hours, the TU Resource Center or the Chemistry Tutoring Center for math or science, but they still struggled in math or science classes. For instance, Amber utilized office hours along with additional resources, however, she still had challenges with the science curriculum at Town University, especially when she did not have a support system for the advanced level science classes. She stated:

I was using the TU Resource Center, the Chem Tutoring Center until they stopped having the higher you go in science the less help there is. The Chem Tutoring Center, they don't have no tutors for Orgo so I really didn't get no Orgo tutors. Also they didn't really have it. And they didn't have it for Genetics.

This limited support from tutoring might have discouraged some African American women like Amber from engaging in advanced science and math classes at Town University. Other African American women were less likely to use office hours, due to work schedules. In the case of

Carmen, she rarely used office hours or studied due to her heavy work schedule. She says, “not studying...I clearly said that I never had to study until I got to Town University. I realized really quickly that I had to study.” To conclude, the availability of resources influenced the persistence of African American women in hard science majors. African American women who used more resources were more likely to persist and navigate through hard science majors than those with fewer resources at Town University.

Academic Advising Support

In college, academic advisors served as a vital support system for the majority of African American women who remained in hard science majors as well. Some African American women received positive and helpful advice from academic advisors regarding seeing instructors in office hours, course registration, filling out proper paperwork, and seeking the proper recommenders for graduate school in hard science majors. For instance, Jennifer explained that “my math advisors were really helpful ... [They said] these are the different teachers teaching this class; these are teachers I think are really good; these are the teachers who I know have this history of whatever.” However, some African American women who departed from hard science majors received negative or limited advice about academic resources (e.g., tutoring, changing majors) on campus from advisors. When asked about the types of referrals given by advisors, Carmen stated “drop out of school, take some time off; stop-out, change your major.” When further probed about feelings after that conversation, she stated “I hated them. I hated everybody that I talked to at one point. That is why I don’t talk to them anymore.”

Equally as important, African American women who remained in hard science majors relied on multiple resources. For instance, they drew on academic advisors, professors, peers, parents, and employers to learn about being successful in college. When asked about how she

learned about being successful in biology, Briana stated, “my academic advisors and then my one professor freshman year. He was really helpful. I would go to his office hours all of the time. He was by far the most helpful of all of my professors ever.”

In contrast, some African American women who departed from hard science majors mainly relied heavily on academic advisors and themselves to be successful in college. No one taught these women how to be successful in the hard science majors. When asked about assistance in the social science majors, as a transfer student, Carmen replied: “they don’t really tell you these are what resources you have.”

Similar to African American women’s experiences in social science majors, health science majors confirmed that learning was more hands-off. Danielle stated that the structure of biology classes is: “lectures, Power Points, I-Clickers, discussions or labs, writing, hands-on stuff, a lot of lab reports.” However, the health science major is more hands-on. She described the structure below.

My first health science class was in Injuries and Sports. We did taping and things like that taking heart rate. In my Health Service Learning class that I have to do the observations. Right now, I am working with an organization where I work with athletes with disabilities or other people with cerebral palsy or another disability. The subjects are more involved.”

From this section it is clear that the hands-off structure of the hard science majors in part accounted for some African American women transferring to health science majors to obtain more hands-on experiences.

To summarize, the availability of resources influenced the persistence of African American women in hard science majors. African American women in hard science majors utilized more resources in college than in high school. On the contrary, African American women in social science and health science majors relied on more resources in high school

science and math classes. They had fewer resources for the college level math and science classes. Thus, African American women with access to multiple resources in college were more likely to persist in hard science majors than those who switched to health science or social science majors.

Theme 4: Cultural Capital and African American women

This section explains subsidiary question three, which looks at African American women's access to traditional²⁵ and non-traditional forms of cultural capital.²⁶ This study found that African American women held both traditional and non-traditional cultural capital in K-16 settings. So, this portion begins with a discussion of the traditional forms of cultural capital. Following that is a discussion of the non-traditional forms of cultural capital including: aspirational capital, linguistic capital, navigational capital, social capital, and spiritual capital in primary, secondary, and/or college. Consistent with previous literature (see Banks, 2009) African American women had access to traditional and non-traditional forms of cultural capital.

Traditional Cultural Capital

In fact, all African American women in this research study accumulated traditional forms of cultural capital in primary and secondary schooling. Traditional forms of capital for African American women in health science, hard science, and social science majors included exposure to music, museums, science fairs, student organizations and clubs in primary and secondary schools. The music African American women listened to while studying in high school ranged from classical to pop, to R & B, and gospel. This is shown in the narratives below by hard science, social science, and health science majors.

²⁵ Recall that traditional forms of cultural capital center on appreciation of middle class tastes such as museums, artwork, and music (Bourdieu, 1984).

²⁶ Non-traditional forms of cultural capital are those that students of color have access to within their communities that create community cultural wealth (Yosso, 2006). These forms of cultural capital include: familial, aspirational, social, linguistic, resistance, and navigational.

I have to think back to the high school artists. I listen to Alicia Keys a lot in high school. She is probably number one. Classical music, I listen to Tchaikovsky; a lot of romantic era artists, or Mozart. (Ashley, biology major).

It would range from hip hop to R & B and gospel and a little jazz. (Raven, health science major)

Everything. It can't be like none of those boring classical music but sometimes I listen to like upbeat classical music. I listen to everything... As far as classical, I listen to a lot of Beethoven and Mozart. I listen to rap music like Rick Ross. He's got a song I listen to. I still listen to it now to study. Everybody. (Celeste, sociology major, formerly pre-business)

I listen to any kind of music except country (Danielle, health science major, former biology major).

These narratives demonstrated that some African American women had access to traditional forms of cultural capital similar to that member of the middle class (see Bourdieu, 1984). Their cultural tastes of music ranged from classical to rhythm and blues, gospel, and even country.

In addition, African American women in health science, social science, and hard science majors went to science museums and/or engaged in science fairs in primary schools. These supported research that tied museums (see Bourdieu, 1984) and even science activities to cultural capital. Some examples of their access to these traditional forms of cultural capital are below.

It was sometime in grammar school. I remember doing the yearly science fair projects with my mom. I had to have been in fifth grade or sixth grade and I did something about gasses that are emitted from plants. That was fun. (Lara, Math major)

We did a science fair in the school. I've been to all the museums that Statesville has except for one. Well, I've been to a Children's Museum of Science. We had a membership there. It's a children's museum. We used to have our birthday parties there. Science was a big thing. The water was my favorite part of the children's museum probably because you got to play with water. It was great. But yeah, we went to all the museums and aquariums and science of all types. My dad used to take us fishing when we were little, so we had aquarium biology. So, my parents, dad especially – wanted to expose us to as much as he could. (Amber, health science major, former biology major)

When I won the science fair at Marian Anderson Catholic Academy in the 7th grade because that was the first project I ever did, and I didn't know what I was doing, but we won...I think I did a project where we wanted to see whether people believed in what they see or what they read. So, we made a book, and we would draw and say, the boy had on blue pants, but we would put black pants on him and at the end we would ask

questions to see if they recalled whether he had blue pants or black pants. (Celeste, sociology major, former pre-business major)

The above excerpts demonstrated that exposure to science and math related activities at museums in elementary and middle school cultivated African American women's interest in these subjects. This is consistent with the literature on traditional cultural capital (see Bourdieu, 1984; Lareau, 2003). Thus, exposure to this cultural capital via these experiences might have encouraged these women to continue engaging in math and/or science in high school and college.

Student organizations and clubs also exposed African American women to science and math through socialization with peers and working on projects. These might be seen as a form of traditional cultural capital as well. Some applications of this follow. Crystal participated in a math club in elementary school. She said: "I was in the math club. I guess that would be it. We did not have any competition based stuff in elementary school. So, I would say maybe the math club, I was proud about that." She further described the structure of the organization. She stated "after school we got together and did our math homework and worksheets. It was a thing to keep us active and not have a competition. It wasn't anything significant that happened at all in it." Similarly, when asked about participation in math clubs, engineering major, Simone responded: "Yes. It did. I did that for like a year." When further probed about competitions, she stated "I went to a couple." In a comparable example, sociology major, Regina participated in a math-related organization. She described that high school club below.

It was for students gearing towards business and business related fields. For my first year, the two events that I did were entrepreneurship. That was how it went. It was two events that students could do, like business, entrepreneurship, or accounting. The first year I did entrepreneurship and some kind of legal something. It was more like an exam that we had to take. The entrepreneurship, which I actually won an award for, we had to basically create a business plan. I created a power point and I had to present it to the judges. I actually won for my first year. That was exciting.

This section confirmed the role of student organizations as hidden forms of traditional cultural capital to socialize African American women for advanced studies of math or science in high school and beyond in college and/or careers.

Equally as important, in college traditional forms of cultural capital that showed up for African American women were music, access to research projects, participation in math or science related student organizations, and conference attendance. Five African American participated in research projects. Of that number three were hard science majors, one was a social science major and the other was a health science major. When asked about comfortably in the research lab, all of the women felt welcomed. This is shown in the narrative of Ashley that follows.

The first time I got there, the professor was herself was really helpful. She was always there, she is in her office just doing work or whatever...Then the grad students, I guess like technicians that might have been there, were all very helpful. You could ask them questions and they were willing to answer them. The grad student that I have been working with for the last few years is like really good.

Similarly, a handful of African American women attended conferences or workshops in STEM fields. Below is a description of a STEM conference that Carmen attended in college. She stated

There were a lot of women there. It was really inspiring. There were a lot of Black women there who achieved great things. So STEM is for women in Science, Technology, Engineering, and Math. So, there were a lot of different women there from different fields. So, it was really inspiring. It was a nice little tea.

Other African American women attended leadership, medical, or student research conferences to socialize them for engaging in scientific activities to prepare them for the workforce. For instance, Kayla recalled a conference in which she presented research. She explained “I was thinking about the diets that they have, they are single mothers. And we did a panel in a dorm about our findings.” These narratives suggested that exposure to student organizations might encourage African American women to stick with hard science majors or health science majors.

Non-traditional Forms of Cultural Capital

Access to non-traditional forms of cultural capital explained why some African American women stayed or left hard science majors in college. The research showed that all African American women had access to non-traditional forms of cultural capital. However, African American women in hard science majors pooled on more resources via non-traditional forms of cultural capital to overcome adversity than their peers in social science or health science majors in college. These non-traditional forms of cultural capital included aspirational, linguistic, navigational, social, and spiritual in primary, secondary, and/or college. The first non-traditional form of cultural capital, aspirational capital is defined as “the ability to maintain hopes and dream for the future, even in the face of perceived barriers” (Yosso, 2006, p. 176). This form of capital is known better as resiliency, which is noted by “the capacity to rebound from adversity strengthened and more resourceful” (Walsh, 1998, p. 4).

The choices that African American women made to stay or forego the hard science major curriculum can be seen as resiliency, which is consistent with aspirational capital. All of the African American women aspired to finish college with a bachelor’s degree from Town University. However, their resilience differed based on the major curriculum. For instance, African American women in social science majors just wanted to graduate with a degree from Town University. They were resilient because they forwent the hard science major aspiration, due to challenges with the curriculum and/or the culture of the science. They also stopped-out at some point in the undergraduate career, but they were determined to obtain a bachelor’s degree. For instance, Regina came back to Town University to finish the degree. Her reasons were the following: “wanting to graduate, wanting to just be done. At least have a college degree. Right

now I am not sure what to do with it.” In fact, she later revealed that she wanted to go to graduate school to prepare for a career in public health.

Similarly, health science majors were resilient by giving up the hard science major, due to the culture of science that devalued hands-on learning. Half of them forwent goals of becoming doctors. In this case their difficulties centered on the absence of hands-on experiences or math or science curriculum at Town University. Despite these hardships, they still wanted to pursue degrees at Town University and careers in health related fields, such as health administration (Crystal), occupational therapy (Danielle), and physician’s assistant (Kayla). Two exceptions to the rule were Amber and Raven who wanted to become doctors.

In contrast, African American women in hard science majors displayed their resilience by continuing to pursue degrees in these majors in spite of adversity due to the science culture at Town University. In fact, they aspired to be doctors (Lara, Shannon, and Rachelle), a researcher (Ashley), businesswomen (Patricia, Jennifer), forensic scientist (Briana), or an engineer in the case of Simone. From this section, it was clear that African American women had access to aspirational capital. Thus, they aspired to engage in majors of their choice and/or careers in the future, which in part explained why they continued to pursue degrees at Town University in spite of barriers.

In addition, the second non-traditional form of cultural capital is navigational capital.²⁷ It differed for African American women in hard science majors and those who departed the hard science majors. For instance, all of the African American women utilized strategies to maneuver through Town University, which was why they were upperclassmen. However, African American women in hard science majors learned how to navigate the science culture at Town

²⁷ Navigational capital enables people to master the “skills of maneuvering through social institutions” (Yosso, 2006, p. 178), such as schools and employment.

University unlike some of their peers who transferred to social science or health science majors. For example, some African American women took introductory level math or science classes at community colleges. Biology major, Shannon recalled:

I took Calculus at a junior college. I got an A...think that pre-Calc does not have a lot to do with Calculus, like you would think. I don't know. I did not really like Pre-Calculus. It might have been the pace of the class. I had already taken Calculus in high school. I knew that material as well. I don't know if it was a difference if it was because I knew the material. Or I know the class was pretty easy as well. I got an A.

They also used tutoring, the buddy system, and office hours to facilitate their success in college math or science classes. In a similar fashion, some exceptions to the rule for non-hard science majors who succeeded in math or science classes at Town University were: Celeste (sociology, formerly pre-business), Raven (formerly biology), Danielle (health science, formerly biology), and Kayla (health science, future chemistry major). What follows are their selected narratives.

I got a B+. I was doing really well up until the final, and I had the flu, so that kind of affected my performance, but the class wasn't hard at all. Pretty straight forward. (Raven, health science major)

Math classes, as far as grade-wise, I would say C+, B- ish. Math, I participated quite a lot, probably just because asking questions. Math is supposed to make everything make sense, but it doesn't make sense alone, so I try to ask as many questions as I can...Mostly in office hours and discussion. I usually ask my peers, because they can put it more in laymen's terms. While the T.A. just talks like the book. (Kayla, health science major)

I think I did pretty good, I don't know what I got for the recent class but in my statistics class I got a B so I guess good. (Celeste, sociology major).

In general chemistry I and lab was a high C. General Chem II, I almost got an A in that class. It was a lot better (Danielle, health science major).

From these narratives what might explain the differences in their continuance in the curriculum was their individual character trait of self-motivation and familiarity with the curriculum.

Furthermore, the third form of cultural capital is social capital.²⁸ It varied for African American women in hard science, social science, and health science majors. In high school African American women in health science and social science majors relied on more resources than the majority of peers in hard science majors. These resources included: parents, teachers, and counselors.

One of the counselors who was my 7th and 8th grade counselor who still made herself available to us. We could go to her, she did not mind us going to her to discuss college or writing a recommendation for college. We also had a postsecondary coach for my senior year. She was a very good postsecondary coach. She actually went to Town University, so those of us who came to Town University, we were able to utilize her more than other people. I think that those people were very good. (Crystal, health science major)

Academic advisor, she told me oh there is this resource. You can go to tutoring. You can go to this. I was very close to her, the academic advisor. (Briana, biology major)

I would say my parents...They're both just very organized. I'd have a test and a project coming up and I'd talk to them about how to get it done. They might say something like, get the beginnings of the project done so that you can study and then do this for the project. (Jennifer, math major)

Regardless of college major, African American women also described their instructors as caring in primary and secondary schools. In elementary school Rachelle remembered her teachers being caring.

They cared about us as a student not only towards our grades. If they saw something was going on outside of class, then they would reach out to you. They felt like second parents, a different group of parents.

Similarly Danielle reported that her elementary school instructors were caring in the following excerpt.

She cared about our class. She came in everyday and she knew what she was going to teach. She was focused. If we were struggling with anything...I know at one point she

²⁸ Social capital is a third type of capital that brings together people (e.g., community members, peers) through providing resources through social networks inside and outside of organizations (Coleman, 1988; Yosso, 2006). Other resources used by African American students include family (e.g., financial support, encouragement, information) school (e.g., norms, relationships) (Conchas, 2006).

had to help me with reading. She helped me out with reading. She was in tune with what was going on at home. So it was more than just the classroom.

These narratives pointed to the supportive nature of teachers in elementary school classrooms and even in some secondary classrooms as noted by the participants. However in college there was a shift in terms of support, they found less support from college instructors. They relied on parents, peers, and mentors for support. When asked about sources of support for success in college, Lara responded “my mom, counselors, graduate assistants, mentors, a lot of people collectively.” Later she was probed about lessons learned, that was when she stated:

That it is hard work and that it is not going to be easy. If you have the determination to do what you want then you can do it. It is not going to be that easy. Networking and finding people who have similar goals to help you get where you need to be. A lot of other things too, but I can't remember right now.

In fact, Lara was one of the few who found support from math instructors. This is shown in the statement below in which she discussed contacts who informed her about succeeding in math in college. She says:

My math instructors. So my calculus III teacher taught me ways to help get the information, writing notes, going to office hours, start doing that stuff in the beginning. Not waiting until if you did not do as well as you wanted to have done, but starting off in the beginning. If you do it that way then it would be better starting off so that you have a cushion just in case you mess up.

The aforesaid text confirmed the important role of teachers and family members as sources of support, especially African American mothers who gave their daughters a nurturing, caring, and supportive environment that was missing from college instructors in college.

Besides parental, peer, and mentor support, African American women relied on a fourth form of non-cultural capital, spiritual capital.²⁹ They used spirituality and religion to overcome obstacles by being resilient in college and thus persist in the science and math curriculum at

²⁹ A lesser known form of cultural capital, spiritual capital is “recognition and reliance on a higher power for guidance” (Aragon, 2006). Verter (2003) points out that spiritual capital has three forms, the embodied (e.g., knowledge about religion) objectified state (e.g., texts, scriptures), institutionalized state (e.g. church).

Town University. Below are two narratives that display the use of spiritual capital in the everyday lived experiences of African American women pursuing science majors.

Freshman year, I still do sometimes. My parents just pray for me... Everybody pray for me. I just know and then they will pray for me so just having that support on my side with my parents, best friends. (Danielle, health science)

I talked to my parents about it...They basically told me that they will support the decision that I made and to pray about it and get back to them. That is kind of what I did and I talked to that friend. It just so happened that we had that conversation me and her always studied together. She was like I am not letting you leave. (Simone, engineering)

These findings are consistent with research (see Patton, 2009; Watt, 2003) that confirmed that spirituality served as a buffer to help African American women cope with challenges of discrimination in college by following the Christian denomination. This research has implications for the use of faith and religion in other studies to better understand if these factors influence persistence in postsecondary settings and how it influences family resilience.

Moreover, some African American women relied on linguistic capital³⁰ in college to switch between their neighborhood and college cultures. The availability of linguistic capital varied for participants based on their home neighborhoods. Consider for example that a handful of participants observed that their peers at Town University acted in opposition to their peers from their home neighborhoods.

You have to be of a certain intellect; a certain kind of person to be here at this university. Something about the university. Something in the air of the name just says regal, high, and mighty, an achiever. What people don't realize is we stigmatize what being an achiever means. We stigmatize, what being intelligent means. I know some very smart people. My friend, Darnell...he is the youngest person that I know to have received is J.D. and he is a lawyer, hood. Hood, like, when I say hood like. Outside of court, his Jordan's with his baseball cap turned backwards, sagging, does not use complete sentences. He talks; he speaks slang. He is not uppity. He is that guy. I think that there is a time and place for everything. (Carmen, sociology)

³⁰ Linguistic capital refers to the "intellectual and social skills attained through communication experiences in more than one language and/or style" (Yosso, 2006, p. 177). In schools, Black children use Black English Vernacular to engage in conversations with Black peers and code-switch, in which they speak in the dialect of mainstream people (Delpit, 1995).

My math classes now, a good majority are Asian or Asian-American, so English is a second language to them. And overall, yes, because my neighborhood is more kinda like a hood. So people speak slang and I can understand it, but I can still speak [and] understand other people as well. (Lara, math major)

When asked to further elaborate on code-switching Lara stated: “Sometimes I just speak however I speak. I don’t know. It changes. Sometimes it’s unconscious, but sometimes it is conscious...” From these findings in order to fit in three cultures, the home neighborhood, undergraduate Black community, and college culture, some women utilized code-switching in the home neighborhoods. There were certain ways of behaving, acting, and talking in the science culture. So access to linguistic capital was important for African American women to use in hard science majors to switch between the science community and the Black community at Town University as well. This is displayed in the narratives below.

... I feel like I am not as close the Black community here, because of my major. I don’t have many of the same classes with most of the African Americans here. So, I am not as close to them, so maybe in social settings at parties I am not the one to talk to everybody. Half of them are in a state where I don’t want to talk to them anyways. So I feel like you make that connection in class. I just don’t’ have that connection. (Rachelle, biology major)

The non-technical majors, I would say. That is what I like to call it. They will be like the engineers, the bio majors, the chemistry majors, we are all kinda of in the same world ... Outside of us, yes they can go out. I am not downplaying them cause I do know that their majors are easier. No, they don’t need to be in the library as much as I do, because they can get good grades with less effort. They can go out more. They can definitely focus on things a little more. Their priorities are a little different so yeah, I notice the difference. (Shannon, biology major).

Based on the aforesaid section it is understandable that some African American women navigated through three different cultures, the science culture, the Black community, and the regular college culture, so partying versus being a serious student. Hence, in order to persist in hard science majors African American women may consider navigating three worlds to experience a balanced college life.

To sum up, cultural capital impacts the persistence of African American women in hard science majors. All African American women had access to traditional forms of cultural capital in K-12 settings. Early exposure to traditional forms of cultural capital centered on trips to museums in primary schools, music and student organizations in secondary schools and college. These early experiences might have cultivated African American women to pursue hard science, social science, or health science majors to continue engaging in math and science in high school and college. To add to that, exposure to non-traditional forms of cultural capital resulted in the persistence of African American women in hard science majors. These included: aspirational capital (e.g., resilience), linguistic capital (code-switching), navigational capital (e.g., science culture), social capital (e.g. contacts in high school and college), and spiritual (e.g., religion, spirituality in college). Limited access to cultural capital, especially in college might have explained why some African American women encountered adversity in math and science classes and later transferred out of hard science majors.

Theme 5: Challenges Faced by African American women Pursuing Hard Science Majors

This section answers subsidiary question four centered on the barriers that African American women face when pursuing hard science majors. More specifically, the Black Feminist Thought (see Collins, 2000; hooks, 2000; Crenshaw, 1995) framework is applied to understand Black women's challenges in their pursuit of hard science majors at Town University. The research confirmed that African American women regardless of major endured hardships in pursuit of hard science degrees at Town University. The challenges that they encountered fit into the following categories: school, home, science peer culture, and science culture environment.

School Environment

School environment difficulties that African American women faced were (1) adjustment to college, (2) racism, and (3) communication. Adjustment to college, more specifically a PWI was an issue that some African American women encountered at Town University in hard science, health science, or social science majors. While some African American women felt comfortable at Town University, other African American women were discontent during some part of their undergraduate careers at Town University. This discomfort Regina and Celeste's resulted in their departure for a year from Town University after freshman year. Jennifer left another PWI due to missing her family. She then transferred to Town University, which was located closer to family members. Other students felt intimidated at Town University as in the case of Carmen. She says: "Town University's campus is huge and it is open. I literally came here and I didn't know anybody. Unlike any of the other schools that I had gone to, they kinda throw you in at Town University."

Equally as important, outside of the classroom some African American women encountered racism. Celeste pointed out "you have days where you're beginning to get involved with people or not get involved. [You] come into contact with a lot of racist people." She continued "and there's going to be people that's very I guess culturally diverse in spirit so you don't have the problems with racist remarks or racist attitudes towards you." To add to that, being the speaker of their race in classrooms showed up as a hardship for some African American women in social science majors. Communicating with peers and instructors who looked different from neighborhood peers were challenges that some African American women faced inside classrooms in hard science, social science, or health science majors as well. In conclusion, the school environment factors of adjustment, racism, and communication with

diverse peers and instructors mainly related to race as shown in the aforementioned narratives of African American women.

Home Environment

The home environment accounted for some African American women's adversity in college. Some of these barriers made these women think about departing from college, especially women in hard science majors. Consider for example when asked about a time, when she wanted to depart the University, Briana replied:

A couple weeks ago when my mom died. I didn't feel like it was worth it...She was my whole like my sole motivation for coming to college was that and the state wasn't going to allow for me to take care of her and my sister by myself at 16, 17 years old. It was like I'm going to find out what's wrong with you. I'm going to be able to take care of you one day. I'm going to be able to; this degree is going to allow me to figure out neurological reasons as to why this disease is happening, why it is progressing.

This quote pointed to the difficult situations in the home that might have deterred participants like Briana from even completing college. Jennifer also departed from another PWI to attend Town University, because she was homesick and missed her family. Perhaps a nurturing environment was absent for these women in hard science majors in college. To sum up, the home environment influenced whether or not African American women engaged in college-level math or science curriculum let alone the hard science curriculum.

Science Peer Culture

In the science or math classes peers accounted for some of the challenges that African American women endured at Town University, due to due to their race and gender. The burden of representation in terms of *being one of the few* African American women showed up as a barrier for the majority of African American women pursuing degrees in hard science majors. Consider for example that some African American women reported experiencing hardships with peers who were different from them inside and outside of science and math classrooms. Shannon

encountered adversity working with her white female peer, due to her inexperience in bio labs.

Shannon explained that experience in the following text.

She kinda had a miss-know-it-all attitude and that was my first Bio lab. So, I was not as familiar with the techniques... I was not the only student...So, she kinda got a little frustrated with me sometimes if I did not exactly know what a machine was. You would be surprised to see equipment that you have never even seen before. She just did not rub me the right way.

Similarly, Jennifer describes her experiences working with the math peers. Jennifer states:

With this buddy thing, I always definitely find a buddy. I've had some mishaps with a buddy in the sense that you find someone, usually not keen to always help someone. I've had that [happen] maybe twice, not that often...Then I'd move on to another buddy. Or I've even had some buddies that started to like then rely on me. It's like well you're not a good buddy now, like I need help. You're not doing anything. And so I move on to other buddies.

In fact, Jennifer later disclosed that she did not associate with those buddies after the semester ended or even for social gatherings. Similar to Jennifer's experiences in math, Lara discussed challenges developing relationships with peers. When asked about relationships with math peers Lara responded: "I guess okay. But I never really knew anybody in my math class. I didn't really work with anyone in my math classes other than when I had an actual discussion." Simone endured hardships when interacting with engineering peers inside and outside of the classroom as well. When asked about relationships with white female peers, Simone responded:

My first couple semesters of engineering classes, I don't think a lot of my peers noticed I was there, or really talked to me, even though we have pretty much all our classes together, but they wouldn't say anything. They wouldn't say *hi* in the hallway or anything... The ones I had all my classes with, it annoyed me, because ...there were definitely a few girls that I remember, we had all our classes together, and it would just be me and them in the hallway sometimes, and I'm like you try to make the eye contact and getting ready to say *hi*, and they would turn the other way...*I'm right here*.

This narrative showed the isolation that some African American women faced in hard science majors with peers. Additionally, some African American women who faced adversity with peers in math or science classes switched to social science and/or health science majors. Consider for

example Patricia's experiences with white male and female (e.g. Indian, Asian) peers. When asked about peer relationships, she states:

Probably the only thing that I would say is the dominant personalities, and the people who think they know everything and not want to use your ideas, that may deter me from ever wanting to work with them again.

Based on this section gender might have accounted for African American women's adversity in interactions with peers. Hence, the burden of representation might need to be addressed so that African American women feel as though they are in a welcoming environment in which they have good working relationships with peers. This in turn might help facilitate their retention and graduation with degrees in hard science majors.

Financial Challenges

Furthermore, some African American women had financial barriers, due to their social class. These included limited funds for books and/or tuition. Some African American women addressed these financial concerns through parental support or by working. For instance, Carmen lost some scholarship funds due to her academic performance at Town University. So, she worked 45 to 60 hours per week at a local hotel in the beginning of the study. By the end of the study she changed jobs and worked between 25 to 30 hours per week.

Other African American women like Patricia, Briana, Ashley, and Crystal also worked between 15 to 25 hours per week between two or three jobs outside of their coursework at Town University. They belonged to working-class or lower-middle class households based on their parents' education and occupations. Additionally, some participants disclosed having financial challenges that prohibited them from getting books for classes or paying for tuition in the hard science majors. Typically, these women came from working-class or lower-middle class backgrounds. This is shown in the case of Regina. She explained:

I know last semester, I did not have my French book for a while. They did something. It was like an extra two weeks before I had a book. That was not good. That was not French too, I was like great. When I don't have my books, you can't do any work.

This narrative demonstrated the role of social class in determining whether or not African American women have books and materials for classes. In contrast to Regina, other African American women lacked financial barriers, but they resisted purchasing books until they needed them for classes. These women came from middle-class families. In fact, this resulted in some of them falling behind in classes at least at the beginning of the term. However, they eventually caught up in the class or later dropped the class if it was overwhelming. In conclusion, financial issues accounted for some African American women leaving hard science majors, due to the inability to pay for the difference in tuition for the hard science major. The inability to focus on academics due to employment obligations, and falling behind in classes due to limited access to books and materials explained why other African American women departed hard science majors as well. Some exceptions to the rule were working-class women like Briana and Ashley who remained in hard science majors in spite of financial challenges. Their reasons for remaining were to (1) obtain bachelor's degrees unlike their parents and (2) move out of impoverished neighborhoods with gang violence and teenage mothers. They exhibited personal characteristics of self-determination and motivation, which might have explained their resilience in hard science majors despite financial barriers that should have distracted their studies.

Science Culture

Other hardships that African American women encountered in the hard science culture were categorized a (1) individual, (2) academic, and (3) administrative. First for many participants, the individual issue of *being the only one* showed up in the interviews as an individual challenge inside the science classrooms. Ashley described this experience in the following excerpt. "There is always the idea that I am one of the few or often the *only one*. So

sometimes, I feel the burden of representation. So, I feel like I will have to work harder than most people. Ashley also discussed her feelings about being the only one. She stated: "...I am used to it. I don't mind it. I accept it. I take it as a challenge and I like proving people wrong or any ideas that they may have. So, I guess that I sort of welcome it at this point." Similarly, Jennifer experienced anxiety when meeting professors for the first time during office hours, due to stereotypes about African Americans. She explained that these feelings stemmed from professors prejudgments about her academic abilities as one of the few African American women in the math major at Town University.

To add to that, African American women pursuing hard science majors dealt with stereotypes about their academic abilities, due to their racial and gendered identities. Below are Amber and Ashley's narratives about peers' stereotypes of their academic abilities.

Yeah, I feel comfortable with my peers for the most part. It was only like a small number of people who I would be like I didn't want to be around only because they just prided themselves on how much they knew about the subject and when you ask questions. They will make you feel *dumb* by like I already know that but you're not the one that asked the question. (Amber, health science major)

Although I do work hard all of the time, but you don't want to be seen as the *dumb Black girl* that does not know anything, cause I am not that. Obviously, I am not going to put that out there. (Ashley, biology major)

From this section peers might have perceived African American women as dumb, so they had to prove their intellectual capabilities. This experience was unique to African American women in the study. Experiences might have been different for their peers who were from different backgrounds based on race, class, or gender. Moreover, Shannon and Kayla discussed others' perceptions of African American women's capabilities

Honestly, on this campus there is an attitude people feel like, I don't know if it is just like a Black thing or what, but they kinda discourage you. They try to tell you, you are gonna

change your major. I had people tell me that before I even got here. They are like you are gonna be a Bio major? (Shannon, biology major)

Whereas my chemistry [advisors], I went in to his office hours once, and he actually told me, I wouldn't say that he told me not to do the major, but he asked me was I fan of math, because there's a lot of math that goes into it, and he wasn't really good at math, so that kind of changed his... perspective. So I'm just like, "What are you trying to say?" (Kayla, health science major, future chemistry major)

From these excerpts being African American and a woman comes with a set of stereotypes about intellectual competence in science communities. These stereotypes might affect the self-perceptions of these women.

Moreover, these stereotypes about their abilities might have contributed to their stress, which might have resulted in hair loss and sickness. When asked about adversity in science curriculum, Carmen and Briana responded in the excerpts below.

My first semester, I failed two, four-hour courses. I only had like sixteen [hours]. So, I may have had a D. It was a biology class and I had a BioChem class... I have been sickly, but I promise, I have never been this sick, back to back. Usually, I am sick because of treatment or because of something else. I am constantly sick here. It is the level of stress that I have experienced here. *My hair fell out.*
(Carmen, sociology major, former biology major)

When I failed, not failed. I got a D in genetics and I got a B-in organic chemistry...*My hair fell out*, I wasn't eating well." (Briana, Biology major)

These narratives displayed how the science culture resulted in health complications for African American in hard science majors. Some African American women experience stress due to the weed-out process of the science culture as well. Briana described the weed out process. "I hated these chemistry courses here because they are just like so horrific. They are weed out courses for primarily the engineers because everybody wants to be an engineer when they come here." Hence, the weed out process coupled with the academic challenges contributed to stress, self-doubt, and a loss of confidence of undergraduate African American women taking curriculum

required for hard science majors. It caused some African American women to depart the hard science majors at Town University as well.

Consider for example that a common experience among undergraduate African American hard science majors was isolation as *one of the few* in hard science majors. Below are some excerpts of African American women who discuss their experiences in the science community at Town University

I guess bittersweet. I mean, sweet to know it's like, I'm still one of the ones that are trying. But bitter in the fact of looking at how many started off. It's like, why are we not excelling as well as other races? (Raven, health science major)

Well in math class I was the only Black girl in my discussion, *only African American*, only person of color. So I was with everybody. But actually I liked working with the Asians with math. We use to joke around a lot about the material, so they made it even better... It feels a little weird. My T.A. knew my name from day one. And I wanted to ask him, do you know my name because you're really good with names or am the only one that looks like me? Is that why you know my name? (Rachelle, biology major)

My lifestyle is so isolating, because it is so intense...It just gets lonely... I sleep. When you sleep, you don't know that you are alone. I sleep or if I am really stir crazy, I will get out of the house. I have a really bad shopping problem. When I am sad, because of loneliness or whatever I shop, which is definitely not good because I can't afford it. I have got really great shoes. Every time I put them on, I feel comforted... It only works for a little bit. You keep doing it, keep doing it, once I run out of money, then I sleep. (Carmen, sociology major, former biology major)

The above narratives suggested that the limited number of African American women peers affects their math and science classroom experiences. In fact some feel lonely, which might result in some psychological issues like stress or depression. Furthermore, the above findings confirm an explanation for the underrepresentation of African American women in hard science majors due to isolation (Justin-Jordan, 2004).

Second, some African American women encountered academic challenges in math and science classes in college. Some hardships that these women endured in college-level math or science at Town University might be attributed to the misalignment of their high school

curriculum. These deficits might explain why some African American women had trouble successfully transitioning from high school level math and science curriculum to college-level math or science at Town University. Shannon confirmed this disconnection with her statement: “this is a school of pretty much hardcore math and science. I came in overwhelmed. I did not feel completely prepared from high school to do well here in the beginning.” When probed a bit more about the adversity in the biology and math classes, Shannon responded:

I did not know how to study. I do not think that I was keeping up with the material the way that I should have. Math, I don't know because, I know that I know the materials. I guess maybe the pace of the class.

From these narratives limited college-level math or science preparation might be due to their attendance at a low resource school. This finding is consistent with research on the connection of academic preparation to African American women's persistence in college (Bradley, 1997; Parrott et al., 2000).

A third barrier that some African American women faced was working with administrators, especially academic advisors. For instance, Kayla described how the health science advisor was more hands-on whereas the chemistry advisor was hands-off and discouraging.

My health science advisor, he goes with me, before I register for courses, he goes through the courses with me. [He] tells me what to expect and helps me be strategic in picking my courses and planning for years to come....He [the chemistry advisor] was just trying to tell me not to do it, or what? So I'm like, “Whether I like math or not, I'm going to major in this.” (Kayla, health science, future chemistry major)

Similarly, Carmen never considered departing Town University. However, her challenges in the science began with advising, when her science academic advisor suggested for her to leave Town University. When Carmen faced hardships within biology, she confided in her academic advisor for guidance. Her advisor provided her with the following recommendations, “drop out of

school, take some time off; stop-out, change your major.” Had she not been an African American woman, she responded, “yeah. I guess that there is a stigma. I don’t think with any other person it would be stop-out of school change your major.” This quote pointed to stereotypes associated with African American women in hard science majors. So, if academic advisors hold negative stereotypes about African American women’s academic abilities in hard science majors, then it may be challenging for some of these women to persist and graduate with a degree in STEM fields due to limited support. This finding supports previous research centered on unsupportive academic advisors for African American women pursuing degrees in hard science majors (see Justin-Johnson, 2004). More importantly, stereotypes (see Steele and Aronson, 1995) might account for some African American women’s departure from hard science majors, because of academic advisors shifting them to different majors based on past performance and/or experiences of African American women in these majors.

Equally as important, the aforesaid barriers accounted for some African American women (1) thinking about departing the hard science major or (2) actually transferring out of the major. Some narratives below support these statements. Briana recalled:

Sophomore year, fall semester. It felt so like okay, choose your torture and you’re either going to make it or you’re not. It was like such a surreal horror movie. Are you really setting me up to fail? I hate this. Why do I have to go through this? Why are these classes so difficult that I can’t even make time for either one of them really?

Similarly, a biology major, Shannon faced adversity as an when taking science courses at Town University. She discussed her hardships in the science curriculum: “after last semester, I got my first D. I have to retake that class this summer.” Despite enduring academic challenges in the science culture, African American women like Shannon and Briana were resilient by never giving up and so they continued pursuing hard science majors. Other peers in social science or

health science majors endured similar struggles in the science and math curriculum at Town University. Consider for example Carmen's narrative below. She said:

I failed drastically. I failed myself. I failed my family. I should have been better and I wasn't better. I was getting the worst scores that I have ever gotten in my life. It got me to a point, where I was like I don't understand... I have experienced so much being here. I am sick all of the time.

The stress from the biology classes coupled with academic advisors ultimately resulted in Carmen departing biology and transitioning into sociology as a major. Similarly another sociology major Regina had challenges in math at Town University, which in turn created a barrier to entering the accounting curriculum. She no longer desired to be an accounting major after her first semester of taking a math class at Town University. When probed a little more about the math experiences at Town University, she responded: "Nothing about the math class experience. I knew that I would have to take more of it... Thinking about accounting their lifestyle is more sedentary, cubicle like and I just didn't want that." Ultimately, questioning oneself, and self-doubt coupled with hardships in science or math curriculum at Town University resulted in former hard science majors transitioning into the social science major of sociology.

Unlike the social science majors, health science majors departed from biology majors for career reasons. This is shown in the cases of Danielle and Raven.

The only reason I did switch from biology to health science was to get a more hands-on experience. I loved biology. I mean science just intrigued me, just the intricate things. They really do bring me back to God, which is amazing you know. These trees are growing like this and I guess just why I love science a lot. Especially the body so crazy how everything works. (Danielle health science major, former biology major)

Everyone is really open to helping each other and helping you and pointing you in the direction to know things. My advisor, she's great. She's always sending me things, even if I'm not in the office, she'll send me things over email: *Hey, I found this. Check this out.* So as far as welcoming and helping and learning about different opportunities, I love health science. The department is really great...I just transferred in my junior

year, and I've learned a great deal that I probably wouldn't have if I had just stayed in biology, mainly because, you know, they just focus on the sciences, saying, *Hey, this is what you need to get to med school with them.* They've kind of given me more opportunities that is not necessarily about the sciences, but that could direct me into that or give me, I guess, the extra that you need to be well-rounded. (Raven, health science major, former biology major)

From these excerpts demonstrated that departure from hard science majors and transition into health since majors was a personal choice that was career related instead of academic preparation as cited in previous literature (see Malcom, 1993). To sum up, African American women encountered hardships based on multiple identities, race (e.g., racism), class (e.g., availability of books and materials, affording the major), gender (e.g., isolation, especially being the only one, health and wellness), and academic identity (e.g., academic preparation). These barriers accounted for the departure of some African American women from hard science majors.

Theme 6: Strategies Used By African American Women Navigating Hard Science Majors

This section addresses subsidiary question five, which addressed strategies used by African American women to succeed in hard science majors. Findings confirmed that African American women who persisted in hard science majors and/or curriculum used multiple approaches. These included: (1) individual faith, (2) school environment, (3) science peer culture environment, and (4) home environment. More specifically this part looks at the methods used by African American women to tackle the hardships in science or math curriculum in college. Following that are some recommendations by African American women to facilitate the success of other African American women in hard science majors at PWIs similar to Town University.

Individual Faith

Individual faith was cited as one strategy that African American women used to navigate hard science majors and curriculum. An example of spirituality can be seen in the narrative of Carmen. Carmen remained silent with regards to her personal and academic difficulties in

biology at Town University. To get through these trying times, she turned to religion. She stated: “a lot of prayer, because I really at the moment that it was going down. I was so ashamed and scared that I didn’t tell anybody until it was all done with.” She continued to say that “lots of church. Lots of prayer. Lots of fasting. Lots of bible reading” allowed her to overcome these challenges and the shame of feeling like a failure at Town University.

School Environment

In addition to individual faith, some African American women in hard science, social science, and health science majors relied on resources available in the school environment (e.g., tutoring) to address their academic difficulties. For instance, when Shannon had challenges with the science curriculum at Town University, she decided to use tutoring at the TU Resource Center to facilitate her success. She said, “tutoring, like I said, the tutors would help me break stuff down. For math, I kinda had to struggle through that class.” Simone also used tutoring for math through an additional class. She described the additional class: “you talk to the teacher, asking questions to the T.A., working that the group that we’re in, helping people or asking if we don’t understand something. I don’t think we did too much board work.” These quotes pointed to the use of resources, such as teaching assistants to understand the materials, which is different from high school where the science and math concepts might have appeared clearer through the direct teaching style. Other strategies utilized by African American women to tackle the rigorous science or math curriculum at the university included: taking classes at community colleges and going to office hours. Thus, it was understandable that African American women, namely hard science majors who utilized more resources were more likely to persist than their peers who used fewer resources in the case of some social science and health science majors.

Science Peer Culture Environment

Equally as important for African American women was the use of peer support through the buddy system in the science peer culture environment. The peers that these women relied on were not homogenous in terms of race or gender. These peers were male or female, African American, white, Asian, and Indian amongst other peers to successfully pass upper level courses in math or science classes at Town University. Consider for example the buddy system as shown by Jennifer and Raven's narratives. A math major, Jennifer describes the buddy system that she utilized in math classes at Town University. She stated:

The first day, I found a buddy and me and this person like check the homework together, studied for the test together, almost every math because I have so many numbers and e-mails of people that are my math best friends and then I met a few more this semester, but I can't name a class where that didn't happen. It's like I do that every year.

Similarly, Raven had a diverse group of study buddies. When asked to describe the study buddies, Raven replied:

They look like me as far as race, majority of them are male. We have one...from a Middle Eastern country. I don't know which one it is, so I don't want to just guess. She is a female. Most of them are male.

This section demonstrated the vital role of peers, especially male peers as resources to facilitate the success in math and science in college classrooms similar to previous studies (see Clewell & Ginorio, 1996; Seymour & Hewitt, 1997; Tyson, Smith, & Ndong, 2010).

To add to that, African American women who persisted in hard science majors debunked stereotypes about their academic abilities. In fact, they fought negative stereotypes about intellectual inferiority through intrinsic motivation and proved their academic abilities to peers. This is shown in Ashley's narrative below.

So, sometimes, I feel as though I have to work harder and I have got to prove more. Yeah, I feel like I guess that I have something to prove. Other people might not see that. I wouldn't want to say that the science department did anything specific to make me feel

like that. I just think that is a general feeling that you get when you are one of few or the only one in a group.

This finding is consistent with research that showed that African American students can remove stereotypes about their academic abilities through stereotype management. According to McGee and Martin (2011) “stereotype management is introduced to explain academic resilience (traditionally valued high achievement in spite of negative intellectual and societal based stereotypes and other forms of racial bias) among Black mathematics and engineering students” (p. 1354). In this study, McGee and Martin (2011) found that “students progressed from more fragile mathematics and engineering identities, characterized by attempts to prove stereotypes wrong, to a more robust form, characterized by a desire to serve as a role model for marginalized learners of color” (p. 1354). To conclude, the science peer culture influenced the persistence of African American women in hard science majors. It was crucial for these women to work with peers who did not look like them and disprove negative stereotypes about their academic abilities.

Home Environment

Finally, family and friends served as important resources to help African American women to continue taking science curriculum at Town University. Amber discussed how her parents and neighborhood family helped her through the trials and tribulations as a biology major. She says, “my parents and people from back home that I talk to when I was going through a rough time. I talked to a lot of people back home more so than here.” Similarly, when Briana endured hardships as a biology major, she consulted her roommate. She stated: “we have similar struggles because the nursing program isn’t very diverse either. So we talk about that a lot—about our common struggles and things like that and it’s very intense.” These quotes suggested

the crucial role of parental and peer support for African American women to persist in hard science majors, cope with stress, and adversity in classes and the culture of science.

To conclude, individual faith, school environment, home environment, and science peer culture account for the persistence of African American women in hard science majors. Some health science and social science found support to continue pursuing bachelor's degrees at Town University as well.

Recommendations for African American Women in Hard Science Majors

In order to inform future African American women scientists, engineers, mathematicians, and businesswomen about the culture of science at Town University, African American women in hard science and social science majors offer some strategies to facilitate their success. This advice includes: (1) individual awareness, (2) school environment, (3) science peer culture environment, and (4) science culture environment.

Individual Awareness

Individual awareness was cited as advice for African American women to use to tackle academic isolation. For instance, a biology major Briana said: "you are going to be one of the *only ones*. Don't be intimidated by other people because you will be very intimidated. Just try to stay focused." Another biology major, Ashley stated that African American women need to acknowledge others stereotypes about their academic abilities. She stated:

I think that they need to be aware of the fact that there is probably a lot of doubt when people look at you, they don't just assume that you are going to be successful. They might assume that you are probably lost and what are you doing in this major?"

Despite this doubt, Ashley encourages Black women to know that "you can be as successful as you want to be... There are definitely people who are always willing to help you no matter what you look like or where you come from." Finally, sociology major, Carmen suggests for African American women to know themselves. She stated:

Know your strengths and your weaknesses. You need to know what you can and cannot do. Do not think that you are invincible, cause you aren't... Don't be so prideful where you can't ask for help. Seek help. You need to be aware that while some exceptions are made for you, the odds are against you.

To sum up, being aware of the issues that African American women face, especially isolation and academic challenges will be advantageous for other African American women to know who would like to pursue hard science majors in the future at a PWI.

School Environment

In the school environment, some African American women offered suggestions to overcome academic challenges and campus climate issues. Shannon's advice to African American women (especially freshman) is summed up in the following statement "I would tell them to study, study, study! That is the key. You have to know your stuff...You cannot B.S. anything." To add to that, a math major, Jennifer also encouraged African American women to seek out a buddy system and be confident. This is summed up in the following sentence.

Just let your capabilities speak for themselves, and then you will get like their respect or whatever. There are people who just want to support you. As long as you care and you take pride in yourself, like people are gonna of course respect you."

Additionally, African American women acknowledged that there might be racism or sexism that you deal with inside or outside of class. A sociology major Celeste stated "you have a lot of people who think that racism is not valid and it doesn't make sense." She continued "if you say something it's racist, you are just being a nit-picker, but in all actuality there are racial undertones in the majority of everything we do." In a similar fashion, she discussed gender:

A lot of men they earn most and they're the leaders, but that's in almost anything. So that would be the most basic thing is just make sure you always state your point and don't let nobody change your mind, or what you have to say, and don't be afraid to be different.

From this section it is evident that African American should be aware of the campus climate via gender and race. This awareness might encourage African American women to find venues for support that address the needs of women and/or African Americans.

Science Peer Culture Environment

To adjust to the science peer culture environment some strategies for African American women to consider are (1) associating with people, (2) balancing academics and social life, (3) networking. First to address the science peer culture, Danielle says: “surround yourself with the right crowd...That’s made all the difference in my college career in being successful is who I surround myself with, who I choose to make part of my company on a daily basis.” In the same manner, Crystal explained the need for balancing social and academic life: She stated “...there’s been people who came in with me from my high school aren’t here, only because they couldn’t find the perfect balance...Also, use the resources. Push yourself.”

Additionally networking and socializing with diverse peers was cited as a strategy to maneuver through science majors. Patricia stated “just basically networking and making sure that she utilizes all of the resources that are set before her to get to know these people that she may need to know, like just staying on top of everything.” Similarly, Raven pointed out that “often times it is not what you know but who you know. Take advantage of every chance that you get to network. You will be surprised at the people that you come across.” In contrast, Simone pointed to making connections with a diverse group of peers. She suggested “definitely make friends quickly get to know people in your classes not just the ones that look like you. You also have to figure out people that are shady there are definitely people that are shady in your classes and in the college.” This narrative points to the need to be aware of the science peer culture environment by acknowledging sources of support versus unsupportive people.

Science Culture Environment

In the science peer culture, African American women made sacrifices to remain in hard science majors. These included sleeping, dating, social life, joining Black sororities, lower grades, and even grade point averages. They also gave up interacting with members of the Black community due to being in the books. This might have resulted in their development of nerd identities. As a young African American girl, a health science major, Raven discussed her thoughts about the nerd identity.

... It took off from there that was the initial interest. After that, I was such a nerd as a little kid, reading random books that were related to the body. Not necessarily like biology or chemistry, but just learning how the body works. My brother, he went to this school, and he is older than me. So, they had random books lying around.

Similarly, in high school, Amber embraced the nerd identity. She says:

Yeah, we worked together alright. We did homework together... We did a lot of working together. I don't like leaving people behind. That's just me. Being my nerdy [self], it's not good to leave the other person behind so. (Amber, health science major)

On the other hand, biology major, Briana accepted her nerd identity in college. She states:

The fact that I don't date. I just don't have time. That I tell guys what my major is and it's like oh okay I see. But it's kind of like oh, you're really smart you know. I'll actually get the *nerd* title you know. It's not attractive.

In essence what Briana gave up remaining in hard science major or engage in science curriculum in the cases of Amber and Raven can be referred to as opportunity costs. Drawn from economic principals, opportunity costs refers to people, places, things, or assets that a person gives up when making decisions in life (Buchanan, 2008; Burton & Kaliski, 2007). These might include the loss of wages, friendships, relationships, and time amongst other things (Jepsen & Montgomery, 2012).

To make it through the science culture at a PWI like Town University, African American women suggested using several resources, including teachers, tutors, and peers. This is shown in the narratives below.

First of all, it is going to be hard. You aren't going to know anybody in your classes. So you will have to take the effort to get to know them and your teachers. Rewriting your notes and starting out at the jump really using the resources that you have to get help with teachers, the TU Resource Center and tutoring finding the tutoring services. (Lara, math major)

I would say making a lot of connections with your teachers and other peers, not just because of the benefits; oh they can put me through here. They can put my name in because they know so much more than you or just being a minority...coming in. One thing that I have noticed throughout the years is that the white people group together always. They are always in the study groups helping each other out. A lot of the African Americans, especially women stay to themselves and study...It is always a secret. Oh I am not going to tell her about this internship that I found out about and excel. So just really network. Everyone is not out to get you. I did not feel that way but I felt other people did. I wish that I would have talked to my professors more. (Rachelle, biology major).

Mentorship was cited as something missing from the science culture by several participants. To address this concern, Kayla stated:

I would definitely take her under my wing and do what the upperclassmen did to me. Tell me about what to expect from certain classes. You have electives and some of them sound intriguing, but really it is a lot of work so you have to choose when you take it. If she is a bio or chemistry major, any of the hard sciences make sure to take down her number and give her your number. Make sure that she calls you if she has any questions. I am all for it.

Hence, mentorship might be helpful for African American women navigating through hard science majors. Equally as important, assessing career goals also showed up as a strategy for African American women considering a hard science major at a PWI. Amber says "first thing I would ask them is what their goal is? Are you trying to go to medical school or are you just trying to get the degree?" She continued:

If you just come in, you have determination but when you look at your schedule, oh cool I'm taking these classes... No! You need to, Pre-Med requirements, what schools you want to go to? Pick out the top five schools. If you're going to medical school, four

or five school you want to go to, look at their requirements, compare them, put them in your schedule, make a four year plan, you'll be done.

Finally, it was important that regardless of the final major that students persevere, which is summed up in a statement by Regina. She explained:

I just thought that it would be so easy. I got accepted, do the work, pass everything, reading, studying, maybe failing an exam here and there, maybe every time. It never really passed my mind until it started to happen. It was like getting discouraged was easy, not realizing that it was about persistence.

To summarize, recommendations for succeeding in hard science majors center on individual awareness of issues of isolation and the availability of resources. The school environment (e.g., academic rigor, campus climate), science peer culture environment, and science culture environment are important for African American women who aspire to pursue degrees in hard science majors at institutions comparable to Town University.

Concluding Summary

In conclusion, commitment to hard science majors is based on (1) persistence, (2) forming partial science identities, (3) availability of resources, (4) access to cultural capital (e.g., traditional, non-traditional), (5) overcoming barriers based on multiple identities, and (6) using strategies to navigate through these majors. To further tease out these findings, what follows is a brief summary. First, persistence in hard science majors is connected to individual interests, namely careers, school environment (e.g., academic preparation), home environment (e.g., parental support and involvement), and commitment to science majors and/or careers. Second, forming a partial science identity resulted in the persistence of African American women in hard science majors due to performance and competence (e.g., intellectual and interpersonal). Less fit in science communities accounted for the departure of some African American women from hard science majors.

Third, availability of resources in primary (e.g. laboratory resources), secondary (e.g., books and materials, laboratory and human resources) was similar for African American women. However, in college African American women in hard science majors pooled on more resources than their peers in social science or health science majors. Fourth, access to traditional and non-traditional forms of capital resulted in the persistence of African American women in hard science majors. Access to traditional (e.g., museums) and non-traditional forms of capital (e.g., social capital, especially social contacts) explained why some African American women continued to engage in math and science classes in high school and college. In postsecondary settings, non-traditional forms of cultural capital (e.g., aspirational, social, linguistic, navigational, and spiritual) resulted in African American women remaining in hard science majors. Less access to cultural capital in college accounted for some African American women departing from hard science majors.

Fifth, African American women encountered barriers inside and outside of the classroom based on multiple identities, including: race, class, gender, and academic. These hardships influenced their persistence in hard science majors. Sixth, strategies that some African American women used to persist in hard science majors included: individual faith, negotiating the school environment, science peer culture and home environment. Finally, some recommendations for African American women succeeding in hard science majors centered on individual awareness, school environment, science peer culture environment, and science culture environment.

CHAPTER 6

DISCUSSION, IMPLICATIONS, AND CONCLUSIONS

Previous research documents minorities and women as underrepresented in hard science majors (see Bowen, Chingos, & McPherson, 2009; National Science Foundation, 2007, 2009). Some explanations for their departure include: (1) individual factors, (2) school factors, (3) the home environment, (4) environment, namely STEM culture, and (5) limited knowledge of careers in STEM fields (see Clewell, Anderson, & Thorpe, 1992; Clewell & Braddock II, 2000; Heppner, Lee, & Wao, 2010; Seymour & Hewitt, 1997; Oakes, 1990, 2005). Reasons why some minorities and women remain in STEM fields are based on individual factors, the home environment, school factors, and even environmental or career aspirations (see Clewell & Braddock II 2000; Hall, 2007; Seymour & Hewitt, 1997; Wilson, 2000).

Moreover, a handful of scholars researched the persistence experiences of women of color and African American women. These research studies found that (1) individual factors, (2) school factors, (3) home factors, (4) the environment, namely the STEM culture, (5) and/or limited access to careers in STEM fields accounted for some women of color or African American women's departure of these populations from STEM fields (see Carlone & Johnson, 2007; Clewell & Anderson, 1991, Jordan, 2006; Seymour & Hewitt, 1997; Warren, 1998). Some explanations for women of color and African American women continuing in STEM fields were based on (1) individual factors, (2) school factors, (3) the home environment, (4) environmental factors, and (5) career aspirations. However, few research studies utilized an intersectional perspective (see Justin-Johnson, 2004) to understand African American women's experiences in hard science majors, especially using a K-16 approach.

To add to that, African American women are among the highest growing populations in higher education. Yet few studies examined why some African American women remain or

depart the hard science majors due to individual factors, school context, home environment, science environment, especially the science culture, and career aspirations. To fill this gap, the purpose of this exploratory qualitative research study was to examine the persistence of undergraduate African American women in science majors at a predominantly white institution, Town University. As stated earlier, the main question that guides this research study was: Why do some African American women at a predominantly white institution persist in hard science majors while others depart from hard science majors?

To address this research question the study employed the frameworks of Black Feminist Thought, cultural capital, science identity formation, and commitment to better understand African American women's experiences in hard science majors. More specifically, the multiple case research study explored whether or not there were differences between African American women who remained in hard science majors and those who transferred from hard science majors to health science or social science majors. The *cases* were the African American women in hard science majors whereas the institutional context was Town University. To summarize, the multiple case study research results, this chapter begins by outlining the major findings from this research. It then discusses the substantive, theoretical/conceptual, and applied implications from the study. Following is a discussion of the limitations of the current study and areas for future research and a concluding summary.

Summary of Main Findings

There are several conclusions drawn from this research study to understand the experiences of African American women in hard science majors and those who transferred from hard science majors to social science or health science majors. These include: (1) persistence in hard science majors, (2) science identity formation, (3) availability of resources, (4) access to

cultural capital, (5) challenges based on multiple identities, and (6) strategies used to navigate hard science majors.

Persistence in Hard Science Majors

Persistence in hard science majors is based on individual interests, school environment, fit in the science culture, and commitment to careers in STEM fields. First, persistence in hard science majors is based on individual interests, namely early interests in math or science beginning in elementary school. Exposure to math or science early on might explain why some African American women continued to engage in math or science initially as a major in college at Town University. Second, some African American women encountered challenges in a college-level math or science class. For instance, some African American women in hard science majors and those who transferred to health science or social science majors questioned their career paths. However, other African American women who remained in hard science majors attributed their persistence in hard science majors to self-motivation. On the other hand, some African American women who were unable to overcome the adversity with the curriculum and pedagogy in the STEM classes at Town University departed from hard science majors and transferred into health science or social science majors.

Third, the school environment had an effect whether or not African American women persisted in hard science majors in college. Some African American women's high school math and/or science curriculum prepared them for college-level science and/or math curriculum at Town University. This might explain why some African American women remained or left the hard science majors. Fourth, parents exposed their daughters to science or math inside or outside of the home. Parental support, especially mothers encouraged their daughters to continue engaging in hard science majors when they encountered adversity. This research finding corroborates previous research that found parents to be supportive of their African American

daughters pursuing degrees in STEM fields (See Jordan, 2006; Warren, 1998). Hence, parental support and involvement accounted for the persistence of African American women in hard science majors. Fifth, parents were supportive of their daughters' decisions to leave hard science majors as well. This finding contradicts previous research that documented the unsupportive parents (see Burke, 2007; Clewell, Anderson, & Thorpe, 1992; Hall, 2007; Tang, 2006) who discouraged women from pursuing degrees and careers in STEM fields.

Sixth, African American women who fit better in the science culture at Town University were more likely to persist than those with less fit in the science culture, especially the curriculum, pedagogy, interactions with peers, and/or professors. Furthermore, commitment to hard science majors was based on career aspirations. So, African American women who committed to careers in STEM fields were more likely to persist in STEM majors than those with less commitment to careers in STEM fields. In summary, African American women with early math or science interests, alignment of high school curriculum with college-level math and science classes, fit in the science culture, and commitment to a STEM career were more likely to persist in hard science majors at Town University.

Science Identity Formation

The findings also suggested that partial science identity formation, especially competence and performance accounted for the persistence of African American women in hard science majors. In primary and secondary schools, all African American women had *intellectual* and *interpersonal competence* in science and/or math classes. However, in college, some African American women, regardless of major, encountered challenges in math or science classes based on the structure (e.g., weed-out system), curriculum, pedagogy, peers, and/or professors. The adversity resulted in some African American women departing the hard science majors and

transferring to social science majors or health science majors. Yet, some African American women who remained in hard science majors continued to engage in the STEM majors in spite of intellectual and/or interpersonal challenges. Performance accounted for the persistence of some African American women in hard science majors as well. For instance, in primary and secondary schools, some African American women showed their knowledge of science through performance, namely class projects, math problems or engaging in science experiments.

Equally as important is *performance* based on class participation. Nearly all of the participants engaged in science and/or math classes in primary and secondary schools through voluntary or forced participation. Yet in college, few African American women, regardless of major, participated in science or math classes due to the class structure. These findings add to research on science identity formation (see Carlone & Johnson, 2007) by understanding the science identity formation of African American women. Finally, some African American women identified as researchers, scientists, or mathematicians. Yet, the findings from this study warrant limited evidence to account for how *recognition* as a scientist by self-identification or through others accounts for the science identity formation of African American women. Hence, more research is needed on how African American women develop the science identity via the recognition process throughout the educational pipeline. In conclusion, forming partial science identities accounted for African American women's persistence in hard science majors or continuing to engage in the science or math curriculum in K-16 settings.

Resources

Availability of resources explained the persistence of African American women in hard science majors as well. For instance, in primary and secondary schools, the majority of African American women had laboratory equipment, books and materials, and human resources. This

finding contradicts previous research that showed that African American girls had less access to laboratory experiments in middle and/or high school (see Bradley, 1997; Hanson & Johnson, 2000; Parrott et al., 2000). The majority of African American women who departed from hard science majors relied on more human resources in high school when they faced curriculum challenges in math or science than those who remained in hard science majors in college. To add to that, in college, African American women who used multiple forms of academic support (e.g., tutoring, buddy system) to overcome curricular difficulties and human resources (e.g., academic advisors, parents) were more likely to persist in hard science majors than women with fewer of these resources. To sum up, these findings provided evidence that African American women had access to resources in K-12 settings. Those resources subsequently played a crucial role in the persistence of African American women in hard science majors in college as well.

Cultural Capital

Access to traditional and non-traditional forms of cultural capital accounted for African American women's persistence in hard science majors. In primary school and secondary schools, the majority of African American women had access to traditional forms of cultural capital, such as music and museums. This contradicts previous research that suggests that only people from middle-class families have cultural tastes of this nature (see Bourdieu, 1984). Additionally, some African American women had access to social capital, such as teachers, peers, and/or parents when they faced difficulties in math or science in high school. This might account for why they continued to engage in math or science curriculum in college. Moreover, in college, non-traditional forms of cultural capital (e.g., aspirational, linguistic, social, navigational) explained why some African American women remained in hard science majors. To add to that, a less developed form of non-traditional cultural capital, spiritual capital played a

significant role in African American women's persistence in science majors. Reliance on faith and religion was crucial when they faced barriers in math or science curriculum at Town University. Some participants' parents prayed for them as well. Thus this might be seen as family resilience. According to Walsh (2002) family resilience "refers to coping and adaptational processes in the family as a functional unit" (p. 14). She continued to say that this "perspective enables us to understand how family processes mediate stress and enable families to surmount crisis and weather prolonged hardship" (p. 14). By utilizing non-traditional forms of cultural capital, these African American women learned how to maneuver through the STEM culture in spite of barriers, which is thus known as resiliency. Yet, less access to non-traditional forms of cultural capital in college resulted in some African American women departing the hard science majors. Thus, these findings add to the literature on traditional cultural capital (see Bourdieu, 1984) and non-traditional forms of cultural capital for underrepresented students (see Yosso, 2006) by understanding how African American women use these forms of cultural capital in K-16 settings.

Challenges in Hard Science Majors

In addition, some African American women faced adversity in hard science majors inside and outside of classrooms based on multiple identities, including: race, class, gender, and academic. In the school environment, some African American women encountered challenges adjusting to a PWI, Town University. This resulted in their departure and/or stop-out from college. Other African American women's adjustment issues in college led them to transfer from other institutions (e.g., HBCU or PWI) to Town University. To add to that, some African American women reported facing racism inside and outside of the college classrooms. This is similar to research on Black women's experiences in STEM majors and/or careers (See Jordan,

2006; Warren, 1998). Equally as important, communicating with peers different from those from their neighborhoods was a barrier that many African American women endured in health science, hard science, or social science majors. Moreover, some African American women had to overcome obstacles from the home environment, especially death or homesickness. Perhaps, some African American women relied on a caring home environment due to the lack of nurturing in the science environment in college as well.

Furthermore, many African American women encountered hardships within the science peer culture. Consider for example that some African American women endured distress working with peers during group projects in science classes. Other African American women had financial issues which resulted in falling behind in classes due to the lack of course books and/or materials or working many hours at work. So social class had the effect of explaining why some African American women made decisions to depart from due to financial issues (e.g., tuition, work, limited books or materials). Finally, as shown in previous research (McGee and Martin, 2011) African American women dealt with stereotypes about their intellectual abilities when they engaged in science or math classes to fulfill requirements for a bachelor's degree in hard science majors at Town University.

Finally, many African American women's challenges in college were attributed to the science culture environment, which is similar to previous research (see Justin-Johnson, 2004; McGee, 2009). These included: (1) being isolated as one of the few African American women in science and/or math classes, (2) rigor of science or math college curriculum, (3) relationships with college administrators, especially academic advisors. Hence these barriers explained why some African American women transferred from hard science majors to social science and/or health science majors.

Strategies to Navigate Through Hard Science Majors

To strengthen the literature on African American women's persistence in hard science majors, this section describes the strategies that African American women use to navigate through hard science majors. These were (1) individual faith, (2) negotiating the school environment, mainly challenges in the science and math curriculum, (3) home environment, and (4) science peer culture, such as working with peers from diverse backgrounds. Equally as important, African American women suggested recommendations success in hard science majors. These focused on individual awareness of issues such as *being isolated or being the only one* in science or math classes. School environment suggestions were studying for rigorous math and science classes and dealing with racism and sexism inside classrooms. African American women provided recommendations for working maneuvering through the science peer culture, such as associating with certain people, balancing academics and social life, and networking as well. Furthermore, to navigate through the science curriculum, African American women advised other African American women to use resources, such as tutoring, teachers, and peers. Finally, they suggested assessing career goals so that they can make sure that they are in the correct major to pursue their ultimate career goals. To sum up, African American women in hard science majors were resourceful and resilient by using strategies to overcome adversity in the science culture. These strategies and recommendations might be useful for other African American women and/or underrepresented students to consider when pursuing degrees in STEM fields at Town University.

Substantive Contributions

This multiple case research study added to the higher education literature on persistence (see Bowen et al., 2009; Perna et al., 2009; St. John et al., 2004; Winkle-Wagner, 2009) by

understanding African American women's persistence in STEM fields via hard science majors. It also extended the qualitative research methodology in higher education research (see Giscombe, 2007; Perna et. al., 2009) by applying the multiple case research study design to understand African American women's persistence in STEM fields, an underrepresented group in higher education. Finally, there is a greater understanding of African American women's experiences within the science culture, based on their multiple identities of race, class, and gender (see Giscombe, 2007; Hanson, 2006; Jordan, 2006; Perna et al., 2009).

Theoretical/Conceptual Contributions

This study contributes to existing theories and concepts by examining how African American women persist in hard science majors. Following is a discussion about the research study adds to theories and concepts, including Black Feminist Thought, cultural capital, science identity formation, commitment for understanding African American women's experiences, and persistence in hard science majors at a PWI. Resilience is also a concept that showed up to explain why African American women persisted in hard science majors, social science, and/or health science majors.

Black Feminist Thought

This multiple case research study strengthens the Black Feminist Thought (see Collins, 2000; hooks, 2000; Smith, 2000; Springer, 2005) framework by exploring the everyday lived experiences of African American women in math and science classes and the science culture in K-16 settings. Typically, African American women spoke about working with peers, both boys and girls in primary and secondary schools. However, in college, they faced barriers working with peers from different backgrounds (e.g. race or gender). Equally as important is the understanding of social class. Access to advanced placement and honors classes, books, and materials was based on social class standing. Some African American women from lower

resource high schools found their high school math or science curriculum to be misaligned with Town University's college-level curriculum. This might have accounted for their challenges in math or science in college.

In contrast, a few African American women from working-class family backgrounds had similar opportunities to gain access to similar curriculum, books, and materials as their peers from middle-class families. To add to that, African American women from middle-class families had access to books and materials for classes and were less likely to be employed. However, some African American women from working-class families held one or more jobs to pay for school or other expenses. Hence, multiple identities of race, gender, social class, and academic were important to understand why some African American women persisted in hard science majors. These identities might have accounted for why some African American women had opportunities to be successful in hard science majors while others were *never meant to survive* in hard science majors.

Cultural Capital

In addition, this research study contributes to previous literature on cultural capital, namely traditional and non-traditional forms of cultural capital (see Bourdieu, 1984, Yosso, 2006) by examining an understudied population, African American women in college (see Banks, 2009). Traditional forms of cultural capital assume that only people from middle-class families have access to cultural tastes (see Bourdieu, 1984). Yet, this study contradicts the aforesaid research by demonstrating how African American women from working-class and middle class families had access to traditional forms of cultural capital, especially museums, science fairs, and music in K-12 settings. To add to that, in a qualitative study, Banks (2009)

found that African American women's access to cultural capital accounted for their persistence and graduation from college.

Equally as important, this study confirmed that African American women had access to non-traditional forms of cultural capital (see Yosso, 2006; Carter, 2003, 2006), including the lesser known form of cultural capital known as spiritual (see Aragon, 2006; Verter, 2003). Non-traditional forms of cultural capital explain why some African American women persisted in math and science in K-16 settings. Consider for example that social capital, especially social contacts, helped some African American women who face adversity in math or science curriculum in high school or even college. Furthermore, in college, non-traditional forms of capital, namely spiritual, aspirational, linguistic, social, navigational account for why some African American women remain in hard science majors in spite of adversity in the science culture due to curriculum, peers, and/or instructors.

Science Identity Formation

This multiple case research study advances previous research on science identity formation (see Carlone & Johnson, 2007).³¹ For instance, the results from this study showed that African American women formed partial science identities based on competence (e.g., interpersonal, intellectual) and performance (e.g. projects, class participation). Yet few African American women saw themselves as researchers, scientists, or mathematicians. To add to that, fewer people recognized them as researchers, scientists, or mathematicians. Hence, Carlone and Johnson's model failed to account for how some African American women or women in general form science identities prior to the undergraduate experiences, especially in K-12 settings. So,

³¹ Recall that Carlone and Johnson (2007) found that women of color who formed science identities during their undergraduate and/or graduate careers were more likely to engage in science careers. From this they developed a science identity formation model that consisted of competence, performance, and recognition. In the model, a person forms a science identity when they have competence in terms of knowledge of science; they perform by engaging in projects utilizing scientific methods. Being recognized by scientists and accepting yourself as a part of the science community is important to the development of a person's science identity.

this research further adds to the discussions on how science identity formation works for some African American women beginning in elementary school. It also advances the concept of science identity formation by understanding African American women's performance by way of class participation and interpersonal competence, mainly working with peers and instructors in K-16 settings.

Commitment

Equally as important, this research study enriches the literature on commitment by examining an understudied population, African American women. Recall that commitment “refers to one's attachment to or determination to reach a goal, regardless of the goal's origin” (Locke, Latham, & Ezez, 1988, p. 24). Becker (1960) observed that some people's commitments are often linked to consistency. Previous research showed that people are committed to occupations or even forming science identities (see Brickhouse, Lowery, & Schultz, 2000; Ritzer & Trice, 1969; Thompson & Windschitl, 2005). Consistent with past studies (see Brickhouse et al., 2000) on commitment, African American women who remained in hard science majors were committed to pursuing careers and/or degrees in STEM fields. Hence, they continued engaging in the major in spite of difficulties. Some health science committed to careers in health science majors. Social science majors committed to obtaining degrees in sociology from Town University, because they stopped-out during sometime of their undergraduate careers.

To add to that, some African American women committed to hard science majors based on access to cultural capital in K-16 settings, resources, and forming partial science identities. By using strategies to navigate hard science majors and overcoming adversity due to their multiple identities some African American women committed to and persisted in hard science majors. Thus, the concept of commitment might be helpful for future researchers who want to understand why some underrepresented groups persist in STEM fields.

Resilience

Finally, this research contributes to the framework of resiliency. Walsh (1998) pointed out that resiliency is “the capacity to rebound from adversity strengthened and more resourceful” (Walsh, 1998, p. 4). Research also confirmed that Black families pulled together resources to survive in spite of obstacles (Hill, 1997; Martin, & Mitchell-Martin, 1978). In educational settings, African American women have been resilient in college to not only survive but thrive on predominantly white campuses as well (Banks, 2009). Similar to previous research, this multiple case research study found that African American women who remained in hard science majors were resilient in that they faced real barriers in the science culture (e.g., curriculum, interactions with instructors or peers), yet they were able to be successful by utilizing multiple resources. To add to that, African American women in health science and social science majors faced the same barriers in the science culture. While they were not as resilient in the science curriculum, they were resourceful by using strategies to persist in college and obtain a degree from Town University. The next section further applies these theories to understand the practices that worked to help or hinder African American women’s persistence in hard science majors at Town University.

A K-16 Approach: From Theories to Practices

As shown in chapter 2, it was important to frame the discussion of African American women’s persistence in science majors by using multiple frameworks. These included: Black Feminist Thought, cultural capital, science identity formation, and commitment. At the end of chapter 2, these frameworks were applied to a K-16 framework in figure 2 (see page 66). Exposure to math and science experiences in coupled with access to cultural capital in K-12 settings impacted African American women’s persistence. The use of resources in K-16 settings influenced African American women’s persistence in hard science majors as well. African

American women who had access to more resources in college were more likely to persist than those with fewer resources.

To add to that, forming partial science identities explained why some African American women remained or departed from hard science majors at Town University. Moreover, all African American women in science majors were resilient. Those who remained in hard science majors displayed resilience by overcoming obstacles in hard science majors. However, those who left hard science majors were resilient by switching from hard science majors to majors that worked for them to obtain a degree from Town University. Finally, African American women who were committed to STEM majors and/or careers were more likely to persist in hard science majors than those who did not have career or STEM major interests. The following section further discusses the applied contributions from this study.

Applied Implications for Policies and Practices in K-16 Settings

Findings from this multiple case research study have several implications for policies and practices in K-16 settings. These include: (1) early socialization in math and science, (2) access to science and math curriculum, (3) teaching and pedagogy, (4) academic support services, and (5) programming. First, parents and schools should expose African American girls to science and math early on beginning in pre-school or elementary school at the latest. This in turn might encourage some African American female teenagers to engage in math and science in middle school and high school. Second, it is necessary for African American female teenagers to have access to advanced placement and/or honors classes to prepare for college-level math and science classes.

Equally as important was for math and science high school curriculum to be in alignment with rigorous college-level math and science curriculum at institutions like Town University. Third, college instructors might consider being enthusiastic and altering science and math

curriculum to use a culturally relevant approach. This might include the contributions of underrepresented groups such as STEM scholars of color and women, especially African American women. Additionally, the use of multiple teaching methods, especially hands-on learning and interactive lectures might engage more African American women in learning materials in math and science in college.

Fourth, it is important to facilitate the use of academic support services for African American women, namely tutors and/or peer support through the buddy system in upper level math and/or science classes. Facilitating study groups that are inclusive of underrepresented groups are necessary for the persistence and retention of this group in hard science majors at PWIs. Fifth, it might be necessary for the development of recruitment programs and retention programs to promote success for students transitioning into hard science majors across the educational pipeline. The K-12 school recruitment programs might expose African American girls to science and math in schools while retention programs promote the use of academic services (e.g., tutoring, meeting with instructors) museums, science fairs, and student organizations. In college, the retention programs might be comprised of college advisors and/or coaches to serve as mentors to African American women, because some of these women might think about switching majors from freshman year to senior year in college. It might be helpful to have someone to consult with during that time. By consultation, some African American women might remain in the hard science majors, especially during sophomore year or even junior year. Being reminded of career goals and aspirations might also facilitate the retention and internally motivate some African American women to continue engaging in hard science majors at PWIs.

Limitations of the Research Study

This study has several limitations. First, it was limited to one research site, Town University. So, there were no comparisons among the experiences of African American women

in hard science majors and those who transferred from hard science majors to health science or social science majors across different PWIs. Second, the study utilized purposive sampling which limited the participants to specific programs, student organizations, or services. The researcher was unable to reach the entire audience of undergraduate African American women who persisted in hard science majors or those who transferred out of hard science majors to fields like social work, humanities and the arts, or even urban planning. Perhaps the use of snowball sampling, especially participant referrals might have generated more participants in a timely manner. Third, by using qualitative research to understand African American women's experiences of persistence in hard science majors, the research could not generalize the findings to a larger population of African American women like larger scale quantitative studies (see Krathwohl, 2004). Fourth, the data collection methods for the study consisted of interviews and journals. So, the researcher was unable to observe the participants or other African American women's participation levels in math or science and/or interactions with peers or instructors in college classrooms.

Areas for Future Research

Given the previously discussed limitations of the study, there are some areas for future research. First, research should be conducted to understand the first-hand insights of African American women in hard science majors across multiple institutions. This might include the case study research methodology, a longitudinal ethnographic study, or even focus groups. Second, researchers might consider engaging in mixed-methods³² studies of Black girls' experiences in middle school math and science; because they might be swayed to really engage in math or

³² According to Creswell (2003), mixed methods involve the use of qualitative and quantitative methods with "both predetermined and emerging methods. Both open-and closed-ended questions... [and] multiple forms of data drawing on all possibilities" (p. 17).

science through their peer groups. Research confirmed that adolescence is the time when students experience the most growth and development (see Erikson, 1980).

Third, it might be helpful to better understand the within group differences between other underrepresented students in hard science fields, especially women, Latino/as, Native American/Indigenous peoples, and Black men. Fourth, to create generalizable findings, perhaps this research study could be replicated and refined using a quantitative methodology to understand if there are differences between African American women across multiple institutions, namely PWIs, HBCUs, or minority serving institutions. Finally, it is important to continue to employ the theoretical framework of Black Feminist Thought coupled with concepts of commitment, cultural capital, and science identity formation to understand why some underrepresented students remain or depart from hard science majors in college, along with K-12 settings, graduate school, or even careers. The gaps from this research provide opportunities for future studies on African American women and/or underrepresented students in STEM majors.

Conclusion

To conclude, African American women made decisions to commit to or forego hard science majors due to access to cultural capital, resources, forming partial science identities, and overcoming barriers due to their multiple identities. This study made several contributions to understanding the persistence and commitment of African American women to STEM fields across the educational pipeline as well. Researchers in K-16 schools, institutions, and policymakers can benefit from the research study by obtaining a better understanding of undergraduate African American women's experiences in the science culture across the educational pipeline based on their first-hand insights.

Consider for example that African American women's recommendations for succeeding in hard science majors may lead to discussions about the implementation of K-16 retention

programs beginning in elementary school continuing throughout college. The aim of these K-16 pipeline programs might be to increase the retention and persistence of African American women in hard science majors as shown by higher graduation rates from PWIs. Second, it offers recommendations from undergraduate African American women's first-hand insights on the culture of science for those considering a STEM major at Town University. It also has the potential to further address the social justice concern of equitable educational and occupational opportunities in the Obama era by explaining how African American women committed to or forewent hard science major curricular programs at a PWI. More importantly, this study provides implications for addressing the underrepresentation of African American women working in science careers in the wider society, which will be important for K-16 math and science educators, researchers, and policymakers. Finally, work still needs to be done to promote equitable opportunities for African American women's access to and success in STEM fields at PWIs.

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