

Winter 2014

# At the College Gates: A Phenomenological Study of STEM Identity Formation at a STEM Program at a Historical Black University

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## Recommended Citation

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**AT THE COLLEGE GATES: A PHENOMENOLOGICAL STUDY  
OF STEM IDENTITY FORMATION AT A STEM PROGRAM AT A  
HISTORICAL BLACK UNIVERSITY**

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A Dissertation Submitted to the Faculty of  
Old Dominion University in Partial Fulfillment of the  
Requirements for the Degree of

DOCTOR OF PHILOSOPHY


EDUCATION

OLD DOMINION UNIVERSITY  
December 2014

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## **ABSTRACT**

# **AT THE COLLEGE GATES: A PHENOMENOLOGICAL STUDY OF STEM IDENTITY FORMATION AT A STEM PROGRAM AT A HISTORICAL BLACK UNIVERSITY**

Maria O'Hearn  
Old Dominion University, 2014  
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Melguizo and Wolniak (2011) contend that increasing the success of underrepresented minority students in STEM fields is a significant national and state policy issue given the data showing gaps in gender and racial/ethnic bachelors degree completion rates in these fields (Rask, 2010). Recommendations made by the National Alliance for Partnerships in Equity (NAPE, 2013) highlight the importance of school structures as being fundamental for improving the STEM pipeline from high school to college for underrepresented minority students. Thus, the purposes of this study were to describe the lived experiences of African American students attending a STEM (Science, Technology, Engineering and Mathematics) Honors college at a state HBCU (Historical Black College and University) and to generate an understanding of a pipeline from high school to a STEM HBCU in shaping their STEM identities. Data for this study were collected through a series of semi-structured interviews from seven students attending a STEM Honors college at a mid-Atlantic HBCU. Phenomenology was employed as a methodology to understand the lived experiences of the participants. Van Maren's (1990) lifeworld existentials were used as a thematic lens to analyze the data. The four lifeworld

existentials are: *lived time*, *lived space*, *lived body* and *lived others*. In coding the data, four themes emerged related to each existential: ability to aspiration, the program as a portal, tensions between race and STEM, and social ties and networks as STEM identity building blocks.

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This thesis is dedicated to my husband, Mike, who has been my biggest supporter. Besides being the chef extraordinaire of the household for the past few years, you've also been a great editor and brainstorming partner.

To my children, Casey, Thalia and Alexi, who have lived with this project.

To my brother, Dr. Basil Vlahopoulos (1950-1987), who will always be an inspiration to me.

## ACKNOWLEDGMENTS

I would like to thank my thesis advisor, Dr.Suh, who has given generously of her time and insight throughout this process. You have kept me on track with my due dates when I easily could have backed down. I cannot thank you enough for all you have done.

Likewise, I would like to thank my other committee members, Dr.Pribesh and Dr. Kimmel. I have taken several classes from each of you during my doctoral process at ODU. You have each been inspirational in your fields as well as being dedicated educators.

A special thanks to my transcriber, Thalia Serino, who was so diligent and patient about representing the participants' voices with precision and care. Also to my son, Alexi O'Hearn, for constructing my graphics. I would like to thank my administration at Maury High School for their support. And big thanks to my colleague, Helen Martin, for being a sounding board for my ideas, giving me a chance to practice my presentations, and reminding me of what I may have forgotten.

I would also like to thanks all the ladies and gentlemen at the MASI program for being welcoming and forthcoming with information, space and their special stories.

## TABLE OF CONTENTS

LIST OF TABLES.....	vii
LIST OF FIGURES .....	ix
INTRODUCTION.....	1
The Research Problem .....	3
The Statement of Purpose and Research Questions.....	6
The Justification of the Study .....	7
Conceptual Framework .....	9
Overview of Chapter Two .....	15
LITERATURE REVIEW.....	16
Pre-College Conditions.....	18
STEM College Programs .....	23
Financial Incentive of a STEM Education.....	25
Bends Along the River.....	26
Social Capital and the Pathways to Higher Education.....	27
Social Capital and HBCUs.....	30
Identity Theory.....	31
STEM Identity in K-12 .....	32
The Development of Science and Math Identity in Higher Education.....	37
The Development of STEM Identity: Tensions and Challenges .....	38
Summary of the Literature.....	42
METHODOLOGY.....	43
Review of Research Questions .....	43
Phenomenology Research Design.....	44
The Context of the Study .....	46
Lessons from the Pilot Study .....	47
The Current Study.....	50
Data Collection .....	56
Data Analysis.....	57
Reliability and Trustworthiness .....	64
Researcher Subjectivity .....	65
Summary of Methodology .....	66
FINDINGS.....	68
Overview of the Lifeworld of STEM students .....	68
Lived Time: Aptitude to Aspiration.....	70
Lived Space: Opening a Portal .....	84
Lived Body: Tension between Race and a STEM Identity.....	97



Lived Others: Social Ties and Networks as Building Blocks to an Identity .....	111
Summary of the Chapter .....	122
Looking ahead to Chapter Five.....	124
<b>DISCUSSION .....</b>	<b>126</b>
Looking Forward .....	127
The Essence of Being a STEM Major .....	128
Constructing a STEM Identity .....	136
Negotiating STEM Identities with other Identities .....	140
Putting All the Puzzles Together: A Bridge to a College STEM Program.....	144
Implications of the Study .....	150
Limitations of the Study.....	152
Closing Thoughts.....	155
<b>REFERENCES.....</b>	<b>156</b>
<b>APPENDICES</b>	
A. Letter of Approval.....	170
B. Request for Participants .....	171
C. Informed Consent.....	172
D. Biographic Survey.....	173
E. Opening Script.....	175
F. Interview Protocol .....	176
G. Summary and Reflection Sheet.....	180
<b>VITA.....</b>	<b>181</b>

**LIST OF TABLES**

Table	Page
1. Characteristics of the Participants.....	53
2. Lifeworld Existentials Operationalized .....	58
3. Initial Codes, Descriptions and Examples of Data .....	60
4. Themes, Codes and Categories .....	63

**LIST OF FIGURES**

Figure	Page
1. Intersection of Social Capital and Identity STEM Formation .....	13
2. Intersection of Lifeworld Existentials and STEM Identity Formation.....	145

## CHAPTER ONE

### INTRODUCTION

...the most urgent social issues affecting people of color today is economic access. In today's world, economic access and full citizenship depend crucially on math and science literacy. I believe that the absence of math and science literacy in urban and rural communities throughout this country is as urgent an issue as the lack of registered Black voters in Mississippi was in 1961 (Moses and Cobb, 2001, p.5)

In the 21<sup>st</sup> century, access to high-quality math and science education matters to all students, particularly students in public urban schools across the United States. In the above quote, Moses and Cobb (2001) equate access to math and science education to a civil right and implore educational systems to empower students of color with knowledge that will provide increased economic opportunity. It is this kind of empowering that has led me to pursue a study of African-American students who choose to attend a STEM (Science, Technology, Engineering and Math) Honors College at a public HBCU (Historical Black College and University). As a high school teacher in an urban high school, I have seen a number of my high-ability competitive African American students choose to attend a selective honors college at a public HBCU. Watching these students has made me question what draws them to this institution offering a STEM course of study and the strength of a STEM pipeline from high school to college. It is against this backdrop that I frame my research.

In February 2012, advisors to President Obama on science and technology presented a challenge to the nation-the United States needed to produce one million more college graduates in STEM fields over the next decade to remain current with a global pace of growth (White House, 2012). The Brookings Institute (Rothwell, 2013) published a report that as of 2011, 20 % of all U.S. jobs require a high level of knowledge in a

STEM field disciplin. In spite of these opportunities, college enrollment in STEM fields continues to be problematic in the United States. Attrition rates are high; only 40 % of students who enter college intending to major in a STEM field complete a STEM bachelor's degree. Thus, a nation with over 300 million people produces only 300,000 bachelor and associate degrees in STEM fields annually (White House, 2012). This shortage of individuals who pursue STEM fields is manifested most dramatically among underrepresented minorities.<sup>1</sup> (American Council on Education, 2006; Museus & Liverman, 2010) with data showing that there are significant gaps in gender and racial/ethnic bachelor's degree completion rates (Rask, 2010). In 2010 the Higher Education Research Institute (HERI) publication titled "*Degrees of Success: Bachelor's Degree Completion Rates among Initial STEM Majors,*" reported the following differences in STEM degree completion rates: White and Asian-American students who started as STEM majors have four-year STEM degree completion rates of 24.5 and 32.4 percent, respectively, whereas, African American students who initially began college as a STEM major had four-year STEM degree completion rates of 13.2 percent. Given the changing demographics of our nation in that 39 % of people under age 18 in the United States are persons of color ( Banks & Nyugen, 2008; U.S. Census Bureau, 2008), the upcoming generation of young people of color represents a significant potential to be tapped for STEM fields of study (American Council on Education, 2006).

Increasing the success of underrepresented minority students in STEM is a significant policy issue on all governmental fronts (Melguizo & Wolniak, 2011; Museus

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<sup>1</sup> See Gonzales & Kuenzi (2012) who use term *underrepresented minority students* to refer to Hispanic/Latino, American Indian/Alaska Native, African American and female students, all of whom are underrepresented in STEM fields.

& Liverman, 2010) as federal, state and private organizations provide resources for institutions offering novel approaches to boost the number of underrepresented students who choose STEM majors. In December 2012 the College Board, in a partnership with Google's Global Impact Awards, announced a \$5 million grant for secondary schools to increase math and science courses for underrepresented minority students in fall 2013 ("Collaboration to expand," 2012). Acknowledging the need for support on both ends of the K-16 continuum, grants have also been awarded to higher education institutions. In April 2012, the Department of Education announced fourteen grants to higher education institutions for a total of \$3.1 million dollars to improve STEM programs for underrepresented minority students who pursue careers in the field and for the preparation of STEM teachers ("ED awards," 2012). In May 2013, nine university teams offering innovative methods to lower the dropout among underrepresented minority students divided \$10 million dollars from Intel and GE (General Electric) ("Lending STEM," 2013).

### **The Research Problem**

As students navigate the road from high school to college, there are many events and decisions that influence their paths along the way with educational structures "constraining or enabling" (McDonough & Gildersleeve, 2011, p.59) an individual student's trajectory. Educational researchers (Maple & Stage, 1991; McDonough & Gildersleeve, 2011; Subotnik, Tai, Rickoff, & Almarode, 2010) emphasize the need to highlight the K-16 perspective when considering the complex interplay of individuals and structure throughout their educational careers. Access to post-secondary opportunities is viewed as a longer-term, interconnected educational process that starts early in a

student's educational experience (McDonough & Gildersleeve, 2011). The recommendations made by NAPE (National Alliance for Partnerships in Equity), a non-profit consortium of state agencies and corporations that promote research and professional development for STEM equity, highlight the importance of school structures as being fundamental to educational success, particularly for improving the STEM pipeline from high school to college for underrepresented minority students. Under the direction of National Science Foundation grants, NAPE developed the following recommendations to address the STEM pipeline: (a) institutional changes to improve enrollment and retention of underrepresented minority students (b) training teachers to improve enrollment and retention strategies (c) providing workshops for counselors to encourage underrepresented minority students and (d) providing additional professional development tools to educators (NAPE, 2013). Accordingly, stretching back to their pre-collegiate experiences and considering environments that enabled aspirations is a worthwhile study (Bowen & Bok, 1998; Maple & Stage, 1991; McDonough & Gildersleeve, 2011) especially in order to understand the processes influencing the proliferation of underrepresented minority STEM students.

When considering school contexts, some researchers (Jackson, 2007) use the term "pipeline" as a metaphor for an educational system that links "all levels of education from pre-K-12 to higher education, the workplace and the influence of the surrounding community" (Jackson, 2007, p.198). The pipeline metaphor provides a visualization of a structure, such as the educational system. The materials that are moving through the pipeline are students and they do so in a variety of ways depending on their status and ability (Jackson, 2007). The pipeline is characterized as problematic for students because

when it falls into disrepair, adequate resources are not invested, leaks occur, and neglect causes students to fail. The term *educational pipeline* addresses the issues of educational conditions in general. Berryman (1983) used the term to analyze the path to a career in a STEM field from elementary school, advancing through high school, then leading to a college degree and a career in the field. Other researchers (Aschbacher et al., 2009; Subotnik et al., 2010) have utilized and expanded the metaphor to consider how experiences and opportunities prepare high school students for college work and subsequent careers in STEM fields. In this study, the researcher is targeting the high school to college nexus as the context of where students' daily experiences take place that may encourage their participation in a STEM discipline.

Thus, the purpose of this phenomenological study is two-fold: a) to understand the lived experiences of African American students attending a STEM Honors college at a state HBCU and b) to generate an understanding of how a pipeline from high school to a STEM HBCU shaped their STEM identities. Identities in STEM disciplines can be strengthened in a particular context by building an individual's sense of their personal worth and competence through recognition (Carlone & Johnson, 2007). Students begin to develop their identities early, making adolescence a critical time for students to assess their personal assets and interests and find appropriate contexts for those attributes (Hoover, 2004). In trying to make sense of the experiences that can potentially shape identity of STEM minded students, identity must be viewed as a long term pathway where individuals are interacting and learning at the same time in a particular context (Lave & Wenger, 1991). Herein lies the interplay between the individual, resources and a sense of who one is becoming, influencing how students see themselves on a career path.



The stories of talented underrepresented minority students in STEM fields can help identify strategies in the social context these students used to navigate the STEM pipeline. Previous studies have identified institutional factors such as pre-college academic coursework, the special characteristics of STEM programs and financial cost of a STEM education. The problem for this study is as follows: what are the socio-cultural factors that are accessible to these students outside of these institutions but are still influential to their decisions in choosing a career as well as in choosing an institution. Phenomenology as a methodological approach allows for listening to students' personal stories; subsequently, educators can better understand what factors influence how students choose their paths of study.

### **The Statement of Purpose and Research Questions**

The present study seeks to explore the STEM trajectories of seven African American students at a STEM Honors college at a public HBCU who attended public high schools. Researchers (Concha, 2006) remind us that there is a need for additional investigation of underrepresented minority students' success stories, as well as research on high achieving underrepresented minority students in STEM programs (Museas & Liverman, 2010). This study adds to the existing literature on underrepresented minority students' STEM pursuit by combining the relevance of the STEM pipeline (Griffith, 2010; Maple & Stage, 1991; Meliguizo & Wolniak, 2011) with research from the perspective of the students themselves (Reid & Moore, 2008) focusing on the sociocultural nature of learning and identity formation. Qualitative research can aid in uncovering environmental factors that assist in the expansion of underrepresented minority students in STEM programs (Museas & Liverman, 2010). Palmer, Maramba and

Dancy (2011) advocated the need to investigate the effective “transition of students of color from secondary to postsecondary contexts” (p.501) especially students pursuing STEM fields as strong high school preparation in science and math frequently emerges as a theme in STEM student research.

Though these findings are informative, there seems to be one significant limitation. Secondary education has a broader role than delivering content. Classrooms are social experiences that shape identities and trajectories throughout the educational pipeline. Filling this gap in research, this study will consider the following as an overarching research question: How did African American students at a STEM Honors College at a public HBCU develop and incorporate a STEM identity from their high school to their undergraduate years? In order to respond to this research question, the following sub-questions will be addressed:

1. What is essential about being a STEM major at an Honors College at a HBCU?
2. What experiences and contexts did they attribute to constructing a STEM identity?
3. How did they experience and negotiate their other social identities with a STEM identity?

### **The Justification of the Study**

This study takes place at a STEM Honors College at a mid-Atlantic public HBCU in an urban area. The pseudonym *MASI* (Math and Science Institute) has been designated for the program in this study. Educational researchers have lauded the achievements of HBCUs as a U.S. institution of higher learning that increases the number of

underrepresented minority students with bachelor's degrees in STEM fields (Bettez & Suggs, 2012; Kendricks, Nedunuri, & Arment, 2013). Even though HBCUs represent 4 % of American colleges and universities today, they produce 30 % of all African American college graduates and 41 % of STEM degrees among African American students (Baskerville, et al., 2008; Kendricks, et al., 2013a). Given the HBCU success rate in STEM matriculation, HBCU STEM initiatives merit further study for secondary and post-secondary educators alike (Palmer, Davis, & Thompson, 2010).

The intention of this research is to generate an understanding of the process by which underrepresented minority students choose a course of study in a STEM field. Research (Koyama, 2007) confirms that what happens in classrooms as students negotiate their pre-college domains informs policies and practices that can enhance potential academic pursuits. By emphasizing the need to understand the effects of student pathways, educators can better understand how those pathways can either eliminate or replicate unequal opportunities and success among some students (Engberg & Wolniak, 2009). Researchers (Maltese & Tai, 2011; Museas & Liverman, 2010; Palmer et al., 2011) generally agree that students who pursue majors in science and math are drawn from high schools where an early interest has been cultivated in those fields by the availability of course work and programs. Varels, Martin, & Kane (2012) argue that building content knowledge does not suffice to increase achievement without a concerted effort to accompany the construction of an academic identity, particularly among students who have traditionally not been represented as successful in certain fields such as math and science. In Cobb's (2004) research on mathematics literacy, he points to math as a course that acts as a gatekeeper to other higher level courses. Addressing the impact of

classroom experiences, he states that “mathematics as it is realized in the classroom also appears to function as a powerful filter in terms of identity” (Cobb, 2004, p.333). Berry (2008) comes to the same conclusion in his research on underrepresented minority students in mathematics. He contends that teaching content must be coupled with a concerted effort to build an affirmative perception of one’s ability towards mathematics and academic achievement, further strengthened by a positive connection between the student and the content teacher (Berry, 2008). Gee’s (2000) identity work acknowledges that identities are tied to the “workings of historical, institutional, and sociocultural forces” (p.100) which is certainly the case for underrepresented minority students going into STEM fields. By exploring the experiences of individual students, how the social world fuels identity is recognized as a focal element of entering a discipline. As there is a dearth of research on how resources from one institution, such as high school, may influence outcomes in college in STEM fields, this research is timely and relevant.

### **Conceptual Framework**

The lack of underrepresented minority student participation in STEM majors heightens the need for educators to consider ways to strategically bolster student participation and matriculation. As this study aims to understand the lived experiences of African American students on their STEM studies pathways and how perceptions of those experiences impacted their considerations of a STEM career, my conceptual framework blends elements of two theories: social capital theory (Bourdieu, 1986) and identity theory (Gee, 2000; Hornsey, 2008; Wortham, 2006). These concepts inform my methodology chapter, guide my interview questions and will frame my subsequent analysis of data. The social capital theory framework guides the research of how K-16

networks and relationships can advance students to pursue and achieve a STEM career. The identity theory guides the research by investigating how students construct an awareness of how they identify with certain career trajectories such as STEM careers. Whereas social capital theory (Bourdieu, 1986; Coleman, 1988; Putman, 2000) focuses on the impact of societal forces such as networks and norms to facilitate one's aspirations by generating valued resources, identity theory acknowledges that individuals form identities over time and their experiences alter those identities. Both these theories acknowledge that learning is a sociocultural process and "identity and academic learning intertwine" (Wortham, p.15). These two frames are compatible ways to conceptualize the significance of K-16 STEM pipeline: schools are social institutions that can be instrumental in preparing students to pursue and complete STEM studies in post-secondary environments; pedagogy and curricular practices contribute to discipline identities (Varelas et al., 2012). Practice and policies that cultivate and nurture those pathways play a critical role in enabling individual outcomes.

From the social capital perspective, networks and relationships are important resources that provide valuable information and support (Bourdieu, 1986; Concha, 2006) allowing individuals to advance socially by the expanse of their networks (Coleman, 1988; Putnam, 2000; Stanton-Salazar, 1997). In educational settings, networks are the product of one's family efforts, making educational attainment based primarily on the capital invested by the family (Bourdieu, 1986), reproducing societal inequities for those who lack familial social capital. Traditional social capital sees individuals without familial social capital trapped in a cycle of educational limitations. Stanton –Salazar (1997) offers an alternate outlook by recognizing special adults in educational settings or

communities who act as informal mentors replacing familial social capital with institutional social capital. Networks and norms in social capital link individuals in a specific social network allowing them to draw on information and expertise that support and promote positive action (Penile & Riel, 2007).

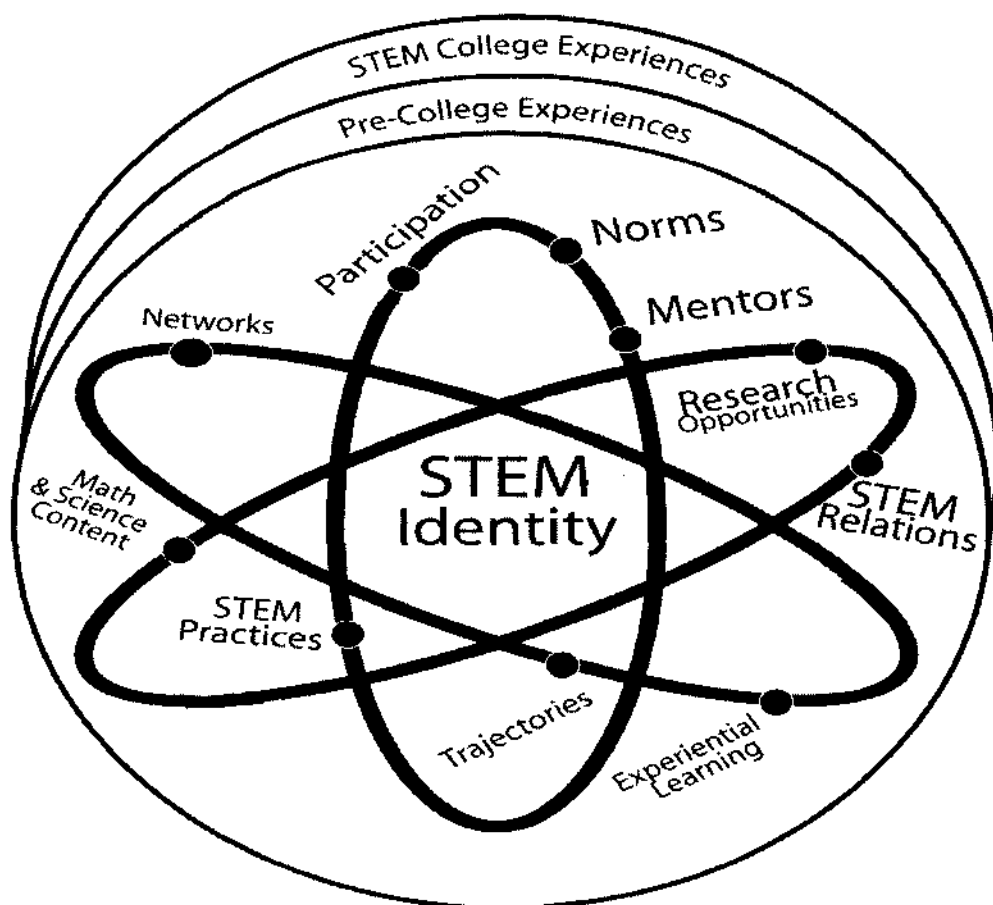
On the other hand, scholarly works (Nassir, 2012; Roth & Calabrese Barton, 2004) confirm that identity is critical in understanding students' commitment and persistence in science and math trajectories. As an individual's identity is formed by experiences and social interactions at home and at school, such interactions shape how students view themselves and, ultimately how others view them. These interactions transmit messages to individuals about what they are capable of doing, shaping their goals and attitudes especially in fields where there is an under-representation of women and minorities (Aschbacher, Li & Roth, 2010). The process of learning goes beyond content information by altering the learner and expanding what they are capable of doing (Wenger, 1998); thereby, making learning an experience in identity formation. Researchers (Gee, 2000; Wenger, 1998) recognize that most individuals have multiple identities connected to their various roles in society. The relevance of identity theory to this study is to understand what attracts underrepresented minority students to pursue STEM disciplines in particular and to develop a sense or "identity" as someone who achieves in these fields.

Science education researchers (Carlone & Johnson, 2007; Roth & Calabrese Barton, 2004) have operationalized the concept of *science identity* as a lens to study the science learning environment, socialization into norms, and how some students can be marginalized in these settings. Similarly, mathematics educators (Nasir, 2004; Varelas et

al., 2012) have made the argument that narrow discipline identities fail to encourage students to explore these areas as career choices. Researchers (Jackson & Seiler, 2013) interested in STEM identities have also operationalized the term *trajectory* in understanding how access to science opportunities over time impacts identity formation and either invites or discourages individuals from joining a community of practice (Wenger, 1998). Using Wenger's (1998) identity trajectories, *inbound trajectories* implies that an individual is accumulating experiences over time, acquiring resources and norms that help them to construct their future identities and join a community. *Outbound trajectories* (Wenger, 1998) imply that an individual is prepared to move out of a community and transform how they see themselves and the world in relation to the community. In educational contexts, students are offered a "personal trajectory" (Wenger, 1998, p.215), where students' identities can be positively or negatively constructed over time through participation in community practices. For the purpose of this study, I have combined math and science identities into a STEM identity as a lens to understand students' perceptions of whether they see themselves as "that kind of person" (Gee, 2000, p.13), as a "doer of math and science" (Varelas, et al., 2012, p. 325).

Social capital theory and identity theory have evolved from two different disciplines: sociology and psychology. From the sociological line of reasoning, social systems and behaviors (i.e. networks) can benefit the individual as they advance in their personal or career paths, hence social capital (Penuel & Riel, 2007). From the psychological perspective, an individual's development is shaped by their circumstances, contexts and relations (Hoover, 2004). These two lines share a common vision, that is, the connection between identity and social interactions. In Jiang and Carroll's (2009) re-

conceptualization of social capital, identity formation and social capital are interwoven concepts as “complementary rather than competitive viewpoints to enrich our understanding of social capital” (p.51). Shared identities among like-minded individuals can lead to social capital bonds strengthened by common goals as well as interpersonal relationships. The authors (Jiang & Carroll, 2009) posit that extensive social capital is facilitated by shared identities. Considering this perspective, bridging social capital theory and identity theory can lead to a better understanding of the nuanced outcomes of social interactions and the influence on students as they consider a field of study in developing their discipline identities.



*Figure 1.* Interaction of Social Capital and STEM Identity Formation

Adapted from Abes, Jones & McEwen (2007) with the authors' permission



Figure 1 was adapted from Abes, Jones and McEwen's (2007) model of multiple dimensions of identity to recognize that at the core of an individual's emerging STEM identity there are overlapping dimensions. Figure 1 highlights the proposed framework suggesting that social capital conditions (i.e. networks, norms, STEM relations) and STEM experiences (i.e. math and science content, experiential learning, research) build on each other during pre-college and the STEM college contexts to result in the outcome of a STEM identity. Norms and networks, before college and subsequently in a STEM college, foster aspirations toward a STEM field of study. During these interactions and social exchanges, ties are being strengthened while identities in a field are being built. By strengthening a STEM identity, the individual assembles experiences (i.e. research, content knowledge), confidence and social ties that serve as an ongoing resource for the individual. The pre-college context serves to start the trajectory from high school to a college STEM pathway that prepares and predispose the student. At the same time, as individuals form a discipline identity, social capital leads to networks that provide resources to expand experiences and opportunities.

These two theories are intertwined with regard to the formation of a STEM identity of underrepresented minority students in this study. For the construction of an individual's STEM identity, there is an ongoing cycle from the individual, to the surrounding educational structures (Varelas, et al., 2012) that socialize the individual into the norms and practices of the discipline. This process of socialization invites participation into a community with the promise of full membership in the future. Over time, learning in various contexts helps shape one's STEM trajectory. From one context to another, such as from high to college, experiences and participation in a STEM

community of practice can prepares an individual to be part of a community while shaping them. These experiences are enhanced by access to networks and information that can increase an individual's participation, hence social capital. How underrepresented minority students negotiate practice and participation with networks and norms develops over time and represents their entry into a STEM identity.

### **Overview of Chapter Two**

In chapter two, I examined the literature that supports my research. Several studies that substantiate the value of pre-college experiences for STEM students were considered. For factors influencing students already in the post-secondary world, I reviewed literature about specific programs created to support underrepresented minority students in their pursuit of STEM studies as well as the finances of a STEM degree. Drawing on social capital theory, I took into account researchers who applied tenets of social capital to students' pathways to post-secondary studies as well as social capital applied to HBCUs. Finally, I explored studies that utilized the lens of identity to consider how underrepresented minority students see themselves as being encouraged or not encouraged in fields such as math and science where they have not been well-represented in the past.

## CHAPTER TWO

### LITERATURE REVIEW

In addressing the implications of preparing underrepresented minority students for higher education, scholars offer a variety of metaphors (McDonough & Gildersleeve, 2011). One that is frequently used is the *pipeline* as a structure that reflects an educational system spanning from K-12 schools to the university (Jackson, 2007). The *pipeline* is a practical one as it can be used to describe stages in the educational process, includes student as well as professional development, and provides a variety of symbols such as pipes and water that may or may not flow freely (Jackson, 2007). Berryman (1983) compared the challenging path to a STEM related field to a pipeline in a seminal study titled *Who Will Do Science?* As Berryman's question focused on the challenges females and minorities face early in their educational experiences, she concluded that overall weak math preparation resulted in the inevitable "leak" in the science pipeline. Her policy recommendations were that underrepresented minority students should be targeted before and during high school (Berryman, 1983) confirming that the pipeline is dependent on "critical junctures, which narrow the pool of students eligible for the next stage on the path to college" (McDonough & Gildersleeve, 2011, p.64).

In a study on race and university admission polices, Bowen and Bok (1998) used the metaphor of a river to consider "the flow of talent-particularly black men and women-throughout the country's system of higher education and on into the marketplace and the larger society" (p.25). Although Bowen and Bok's (1998) book addressed the issue of race as a factor in admitting students to selective colleges and professional school, there are several points of their work applicable to this study. For instance, the pipeline

metaphor recommends that an awareness of weaknesses in the educational system can provide policymakers with tools to implement effective interventions (Jackson, 2007). In the same way, the river metaphor considers the process of moving young people towards a defined goal as a passage where resources and behaviors in the educational process aid students to navigate that process (Bowen & Bok, 1998). The difference between the two images, however, is reflected in the case of the passage. The pipeline metaphor is criticized for implying that the passage is “smooth, well-defined and well-understood” (Bowen & Bok, 1998, p.1) whereas the river is unpredictable, winding, full of unforeseen perils. Bowen and Bok (1998) view this unpredictability as being a more realistic reflection of the issue of race in educational outcomes. For the purpose of this literature review, I intermingle the river metaphor with the pipeline metaphor as it seems appropriate to the specific context of this study.

Being HBCUs hold an important role in the matriculation of STEM students in U.S. higher education (Baskerville, et al., 2008; Kendricks, et al., 2013), it is critical to understand how the “flow” of that talent has been nurtured. In order to generate an understanding of that “flow” and the intricacies involved in navigating a river of learning and becoming, this study addresses African-American students attending a STEM college at a public HBCU who constructed their science and math identities over the course of their K-16 experiences and traversed the STEM pipeline. Previous research suggests that factors that influence the STEM pathways of underrepresented minority students fall into three categories: a) pre-college conditions such as individual and school level factors; b) STEM college programs with specific opportunities and support structures and c) the cost of a STEM college degree (Aschbacher et al., 2009; Crisp et al., 2009; Griffith, 2010;

Kendricks et al., 2013; Rask, 2010; St. John & Noell, 1989). From the formation of aspirations to the creation of a career identity, students are presented with an array of influences. Current literature addressing those three topics will be discussed in this chapter.

As this is a phenomenological study, I will explore the lived experiences of African American STEM students from a high school to a college pipeline (Adelman, 2006; Aschbacher et al., 2009) also referred to as the high school to college nexus. I will draw on literature that reflects two components of the study's conceptual framework- social capital theory and identity theory based on how these theories relate to STEM aspirants. Prior research using social capital theory and identity theory will be considered to examine how networks, social ties and STEM identities influence underrepresented minority student trajectories and pipelines to post-secondary education and identity formation in STEM fields.

### **Pre-college Conditions**

Drawing again from the metaphor of the river used by Bowen and Bok (1998), the authors urge readers that it is necessary to understand the entire shape of the river to understand the lives of students and their career choices. Students bring prior academic achievement and experiences to college with those experiences influencing their college success and chosen major (Crisp et al., 2009). The impact bears significance for STEM majors because content learning and identity construction are intertwined (Varelas et al., 2012).

Previous studies indicate that students who choose to pursue STEM majors in college and successfully matriculate within six years are students who showed a STEM

inclination in high school (Maltese & Tai, 2011). In a longitudinal study of 4,700 students in U.S. schools, Maltese and Tai (2011) administered three surveys (i.e. 8<sup>th</sup>, 10<sup>th</sup> and 12<sup>th</sup> grades) asking students to report on the level of interest in certain specific subjects over time. This research project focused attention on students' inclination in the STEM pipeline, concentrating expressly on school level factors. In their findings, they concluded there was a positive correlation between the number of science courses taken in high school and a STEM degree. The participants in the Maltese and Tai study were predominately Caucasian. On the other hand, Maple and Stage (1991) addressed the issue of underrepresented minority students choosing math and science majors by employing a model of math and science choice with a sample of 2,456 African American and White students at a community or 4-year college who reported an interest in math or science in previous studies. The researchers concluded that for all subgroups, the math and sciences courses they chose from their 10<sup>th</sup> to 12<sup>th</sup> grade in high school had "significant direct effects on the field of study in college" ( p.45). Both studies indicate that student experiences in high school math and science courses affected their likelihood of earning a STEM degree.

Similarly, Engberg and Wolniak (2013) conducted a study drawing on data from a national database to consider individual and school-level factors that had the most influence on the probability of students choosing a STEM major transitioning from high school to college. With a sample of 4,180 students, 670 high schools and 1,050 postsecondary institutions, these researchers confirmed that when taking into account race, gender and SES, high school preparation in STEM classes in high school was significant in strengthening a STEM predisposition to a college major. Their results

validated findings from comparable studies that academic preparation and course taking are essential components in increasing STEM propensity for underrepresented minority students (Engberg & Wolniak, 2013).

Crisp, Nora, and Taggart (2009) considered factors leading students to choose a STEM college major and persisting at a Hispanic Serving Institution (HSI) using institutional data files from a sample of 1,925 students applying previous research to a specific demographic. Employing a Student/Institution Engagement Model, the researchers considered pre-college characteristics and high school academic achievement as indicators of perseverance in a STEM career. These researchers pointed to first semester STEM college courses which acted as “gatekeepers” (p.937) and negatively impacted on students’ future choices. The probability of matriculating in a STEM field was positively correlated to enrolling in Biology I or higher during a student’s first semester of college bearing out the significance of secondary school course work for post-secondary preparation. Their results confirmed prior studies that STEM high school achievement positively influenced STEM results at a HSI, altogether indicating that pre-college factors such as taking advanced science in high school influenced the choice of a STEM major among underrepresented minority students.

Providing educational environments that stimulate STEM interest during pre-college years has been touted as successfully sustaining STEM interest to pursuing a college major (Maple & Stage, 1991; Subotnik, et al., 2010, Rask, 2010). Researchers contend that school programs promoting socialization into academic and career cultures increase access to social capital and reinforce college-going norms particularly among underrepresented minority students (Concha, 2007; Stanton-Salazar, 1997). Exposing

students to strong content knowledge in math and science as well as peers who share interests in STEM fields are likely to increase confidence and success in STEM fields (Subotnik, et al., 2010).

One such program developed a partnership between the University of Kentucky's School of Engineering and the Jefferson County Public School (JCPS) where students were exposed to engineering curricula in elementary and middle school programs (Ralston, Hieb, & Rivoli, 2013). Modeling the pipeline principle, the program was extended to reach the area high school that these students would eventually attend as well as hosting a summer camp. Participating schools drew from diverse populations (50 % minority population). The program grew over a four year period expanding to 15 schools and over 1,800 students. Although the researchers admit it was too early to evaluate the long range accomplishments of the program, a quantifiable factor pointing to the program's success was a significant increase in the number of students applying to the math and science magnet high school from the engineering feeder schools. This study serves to illustrate the significance of being familiar with academic norms and the process of strengthening a critical STEM pipeline that encourage students to pursue math and science studies.

Brody (2006) suggested that middle school and high school STEM pipeline development programs should be measured by short-term and long-term outcomes. From the short term perspective, a program would increase a student's content knowledge of scientific principles, enhance excitement toward the discipline, and develop workplace awareness of math and science careers on the part of the participants. From the long term perspective, a program would encourage high achievement in rigorous math and science



courses in pre-college years encourage students to select STEM majors and early entry into STEM fields. The implications for practice are that increasing students' participation in STEM magnet programs does work and the programs "have played a defining role in decision-making about the direction their lives have taken" (Brody, 2006, p.5). Although Brody (2006) does not specifically address underrepresented minority students, college majors serve as noteworthy indicators of career targets for all students.

Stolle-McAllister's (2011) research on the summer bridge program for Meyerhoff Scholarship Program (MSP) at the University of Maryland Baltimore County (UMBC) serves as a noteworthy starting point to discuss high school to college transitions for underrepresented minority students. The MSP at the UMBC is a highly acclaimed program recognized for promoting underrepresented minority students in STEM fields (Stolle-McAllister, 2011). This qualitative study centered on how characteristics and strategies of the summer bridge program reflected elements of Bourdieu's social capital and the resulting influence on students' STEM propensity. A group of high achieving African American students attended a six-week residential program prior to their freshman year taking college science courses, participating in professional development seminars, visiting laboratories and meeting with science professionals. The research team (Stolle-McAllister, 2011) interviewed 134 current and prior participants of the MSP-ranging in experiences from students who just entered the program through the summer bridge program to former students who had graduated and held PhDs. Using focus groups as their method of interviewing, the protocol centered on how the students perceived that the MSP worked for them. The MSP, starting with the summer bridge program, developed the students' social capital by emphasizing keys elements of the

theory such as trustworthiness, networks, and norms. Stolle-McAllister (2011) concluded that students who did not have access to social capital through family connections could find a productive capital through strategic programs such as these.

### **STEM College Programs**

To address the low numbers of underrepresented minority students who graduate from STEM programs, researchers (Kendricks, et al., 2013; Palmer et al., 2010; Schwartz, 2010) have considered the impact of mentoring, undergraduate research opportunities and program initiatives that promote the success of underrepresented minority students in STEM fields at HBCUs. Palmer et al. (2010) focused on how four different initiatives used a student affairs retention theory to construct their unique STEM programs. Coordinators who were interviewed for the study attributed the success of their strategies to the principle that “students must be academically and socially integrated into the college context” (p.442). The strategies promoted by these programs combined tutoring, web-based math teaching and testing, and mentoring workshops. Researchers found that by strategically creating supportive academic environments, STEM student retention increased.

Kendricks et al. (2013) investigated a similar plan, the Benjamin Banneker Scholars Program (BBSP), to address the issue of retention and graduation in STEM programs. The key elements of the program were: requiring students to live in a designated dorm, apply to and attend a STEM internship, and meet monthly with a mentor. Data results from student surveys found that, in addition to the overall benefits of the program, “structured mentoring” (p.38) had the most impact on the success of graduating students, thus emphasizing the benefit of supportive environments.

In a study (Slovacek, Peterfreund, Kuehn, Whittinghill, Tucker, Rath, & Reinke, 2011) sponsored by the National Institute of General Medical Sciences (NIGMS), the Minority Opportunities in Research Division (MORE) funded three public universities to support minority students studying science. The MORE programs focused on four aspects of underrepresented minority students in STEM programs: research experience, mentoring and advising, supplemental instruction and financial support. This study involved 430 graduate and undergraduate students enrolled at three universities over a three-year period to evaluate the strength of their program interventions relative to the principles of MORE. Among the results, students who had the opportunity to communicate about their research by presenting at a conference had a greater sense of motivation and preparation for future STEM studies. Belonging to a community of practice (Wenger, 1998) benefited the participants creating networks for future opportunities and educating about the norms and conventions in their fields. Even though participating in research was a requirement of the program, having a faculty member who acted as a mentor in one's research had a significant impact on a student's overall success.

Similarly, Schwartz (2012) conducted a qualitative study of undergraduate research and mentoring relationships at a predominately African American (but not designated as a HBCU) university. Investigating four pairs of faculty and student research partnerships in STEM disciplines over a 2-year period of time, the results indicated that the undergraduate research and mentorship were "impactful" (p.535) for the participants by expanding their knowledge of science and retention. In all three studies about underrepresented minority students in STEM programs, students reported

substantial benefits from mentorship with faculty, particularly when combined with research opportunities.

University STEM programs that address the retention and persistence of underrepresented minority students concentrate on the post-secondary end of the pipeline. Participation in mentoring and research programs sustains an interest in the discipline as well as providing opportunities to build valuable social capital networks for future professional ties. Furthermore, these partnerships contribute to building a STEM identity among the participants inviting them to engage in a practice as part of a discipline related community expanding the possibilities of their new identities (Wenger, 1998).

### **Financial Incentives of a STEM Education**

A number of studies suggest that financial support represents particular concern to underrepresented minority college students, especially in STEM fields (Perna, Lundy-Wagner, Drezner, Gasman, Yoon, Bose, & Gary, 2009; St. John & Noel, 1989; Stolle-McAllister, Domingo & Carrillo, 2011; Whalen & Shelley, 2010). With regard to college in general, St. John and Noel (1989) found that financial aid had “significant and positive impact on enrollment decisions” (p. 578) and in “promoting access for minority students (p. 579). In a case study of women pursuing STEM careers at Spellman (Perna, Lundy-Wagner, Drezner, & Gasman, Yoon, Bose & Gary, 2009) one of the themes that emerged from their research was that “financial barriers limit the persistence of Black women in STEM fields” (p.8) making financial aid the greatest challenge to attaining a STEM career. Stolle-McAllister, Domingo, and Carrillo (2011) measured the overall insights of current students and alumni in a particular STEM program at a large public university. Financial aid is an even greater consideration for STEM majors-as there is a perception

that it takes longer to complete due to the difficult coursework (Stolle-McAllister et al., 2011). Further studies (Whalen & Shelley, 2010) verified these findings, as underrepresented minority students were relieved of financial pressures, they did not have to work long hours outside of the university and could devote their time to study and research. Whalen and Shelley (2010) expanded the idea of financial aid to include campus work-study programs that kept STEM students close to campus life, especially residential learning communities. As many STEM majors require graduate school to complete career aspirations, the issue of debt is decisive especially among first generation college students (Whalen & Shelly, 2010).

With the goal of strengthening the STEM pipeline for underrepresented minority students entering these careers, financial aid contributes a great deal to retention and persistence to graduation (Navarra-Madsen, Bales, & Hynds, 2010). Economic matters influence the development of a STEM identity by allowing students more time to participate in professional organizations and research projects that enhance their professional competences. Financial aid coupled with academic support can remedy a “leaky pipeline” (Navarra-Madsen et.al, 2010, p. 463) by creating a sense of possibilities and opportunities within an educational system.

### **Bends along the River**

The pre-college to college time span can provide researchers with an understanding of “what bends along the river” (Bowen & Bok, 1998, p.275) underrepresented minority students experience when they make certain educational choices. Previous studies have identified factors such as pre-college academic coursework, the special characteristics of STEM programs and financial cost of a STEM

education to address the underrepresented minority students' enrollment and matriculation in STEM fields. As students move through this pathway, migration into and out of the STEM pool provides a strong link to who will persist (Berryman, 1983). Most studies employ large data bases exploring a wide variety of initiatives and support programs to measure persistence. This study is examining the socio-cultural factors that are accessible to these students outside of these institutions but are still influential to their decisions both to choose a STEM major and to pursue a STEM career at a particular institution.

### **Social Capital and the Pathways to Higher Education**

Although social capital theorists offer a variety of definitions of social capital (Aguilar & Sen, 2009), there is agreement that networks provide valuable information and support for individuals who can access this intangible resource (Concha, 2006). Bourdieu (1986) characterized the strength of social capital as the possession of "a durable network..." (p.248), and Coleman (1988), lauded the benefit of networks as relationships "among persons that facilitate action" (p.S100). In the same way, Putnam (2000) contended "social networks have value" (p.19) allowing individuals to advance by the reach of their networks (Stanton-Salazar, 1997). When applied to education, networks can be the product of one's family efforts, making educational attainment based primarily on the capital invested by the family (Bourdieu, 1986), and not necessarily one's own attributes. Coleman (1988) added "norms" (p.S104) and widened the reach of influence to other societal sectors beyond the family, such as teachers. Accordingly, when one maintains networks or relationships, important information can produce a "basis for action" (Coleman, 1988, p. S104). Norms, as acceptable forms of behavior, are

reinforced over time as acceptable and commendable. Conversely, Loury (1981) saw social capital as damaging, an extension of “public goods” (p. 125), such as education and jobs, to young people by way of family influence. Pessimistically, social capital serves to perpetuate societal inequity and racial income inequality by rooting economic access on the “economic success of the individual’s parents” (Loury, 1981, p.125). Similarly, Lareau (2000, 2003) illustrated Bourdieuan concepts of social capital, networks and norms that produce consequences favoring privileged groups instead of building capital for all students. Lareau (2000, 2003) debunked the idea that our schools are classless and studied how higher income families have greater funds of social capital and use these resources to give their children intellectual and economic advantages. Accordingly, social class is a decisive influence on connections between families and other social institutions, such as schools.

Alternatively, there are examples of research that link social capital to underrepresented minority students’ success in general, as well as college pathways. Stanton-Salazar (1997) alone and in collaboration with others (Stanton-Salazar & Dornbusch, 1995; Stanton-Salazar & Spina, 2003) presented a perspective based of social reproduction (Bourdieu, 1996) by exploring the relationship between schools and minority student achievement. Stanton-Salazar’s (1997) research features a schema that entails the analysis of “interpersonal networks” (p.3) and institutional life that extends benefits to minority students. Stanton-Salazar (1997) suggested that students who are outside the dominant group develop strong relationships to institutional agents as part of an explicit and purposeful agenda. Schools develop social capital when strong social and institutional relations allow students access to “knowledge based resources” (Stanton-

Salazar & Dornbusch, 1995, p.119) like applying to college. Ties to “non-family institutional agents” (Stanton-Salazar & Dornbusch, 1995, p.131) are indicators of the significance of special adults in the community who act as informal mentors and the importance of supportive relationships with non-familial adults as “network transformations” (p.250).

Addressing the issue of underrepresented minority students preparing for college, Gonzales, Stoner and Jovel (2003) used social capital as a framework for understanding the college decision-making process of Latina seniors. Gonzales et al. (2003) created a scale of social capital by placing a value on the extent of support made available to students, coining the idea of a “high volume agent” (p.165), concluding that high volume social capital carried out by institutional agents had positive results. Enriquez (2011) examined the path of undocumented Latino youth finding that immigrant students framed their schools networks as their “families” (p. 477) that guided them through the college application pipeline confirming the critical role of teachers who encouraged them by promoting college going processes.

For underrepresented minority students, the “bends in the river” (Bowen & Bok, 1998) metaphor directs attention to the process of choosing and pursuing higher education options. At each stage in the process of going to college, students are “siphoned out of the flow” (McDonough & Gildersleeve, 2011, p.64). For students demonstrating a STEM potential, social capital widens the ability of individuals to acquire benefits and information from institutional networks through difficult tributaries. For students who do not have familial-based social capital, extra-familial support and relations take on added significance to ensure that college access is not focused on K-12



or the college level, but on an expansive approach that creates a strong K-16 bridge. (Simmons, 2011).

### **Social Capital and HBCUs**

Brown and Davis (2001) have applied the social capital framework to the study of students who attend HBCUs developing the idea that networks and norms can be used strategically to create capital in a specific context. They called HBCUs “purveyors of social capital” (p.40) since they impact specific “sociocultural resources and networks” (p.40), seeing HBCUs as constructing relations and networks that translate to future social capital. Through successful matriculation, individuals gain entry and status in certain professions and social circles (Bourdieu, 1986) thus, creating social capital within the African American community for those who have completed a university degree. Palmer and Gasman (2008) draw from Brown and Davis (2001), applying this framework to a qualitative study of African American men attending a public HBCU. These authors (Palmer & Gasman, 2008) concluded that HBCUs are “rich in social capital” since professors and administrators were accessible to students, formed supportive relationships with students, mentored and served as role models to the young men in the study (Palmer & Gasman, 2008, p.66). The research on social capital as a theoretical framework to study HBCUs portrays social capital as a by-product of a particular institution. Accordingly, an institution builds capital to propel students in a particular direction, which differs from students accessing social capital while considering college pathways. Evidence suggests that social capital and educational outcomes are positively linked (Dika & Singh, 2002).

Thus, borrowing from the principles of social capital, this study proposes a lens identified as a *STEM social capital* to describe the ways that networks and norms apply to the experiences of underrepresented minority students applying to a STEM college. Social capital works because “embedded resources in social networks enhance outcomes of action” (Lin, 1999, p.31). Strengthening resources and networks can produce increased student outcomes in choosing STEM disciplines and careers. In a *STEM social capital*, social networks enhance mentoring and community based STEM experiences by introducing norms of STEM study-academic rigor and preparation. Moreover, future career goals and interest would be augmented by developing academic credentials in STEM disciplines such as internships and research.

### **Identity Theory**

Gee (2001) promotes the concept of *identity* as one with great potential for 21<sup>st</sup> century educational researchers. *Identity* is what sort of person we are in the context of a variety of settings such as school, home or work, a kind of “performance in society” (Gee, 2001, p.99) or “contextualization” (Wortham, 2006, p.32). One’s identity is subject to an “interpretive system” (Gee, 2001, p.107) that is understood through historical and cultural perspectives. In identity formation, two processes take place: self-categorization and social comparison (Stets & Burke, 2000). Wenger (1998) frames identity in a similar direction: initially, the focus is on the individual from a social standpoint; then, expanding the focus to the wider development of how one is identified and the social construction of that identity. Identity occurs from the “mutual construction” (Wenger, 1998, p. 146) of the self and social forces surrounding the individual, thus making the

concept of *identity* an effective tool for generating understanding of how schools and society intertwine (Gee, 2001).

Similarly, in conceptualizing the issues of STEM identities and underrepresented minority students, Wenger (1998) most adequately illustrates the complexities in the process of their identity construction, which involves the individual and the social communities that the individual belongs to:

The resulting perspective is neither individualistic nor abstractly institutional or societal. It does justice to *the lived experience* of identity while recognizing its social character-it is the social, the cultural, the historical with a human face (p.145).

As this is a phenomenological study, I was drawn by the use of the term “lived experience.” At the same time, the purpose of this study is to explore the lived experiences of students attending a particular institution with a significant historical foundation such as HBCUs. Hence, this important quote encapsulates for me the dichotomy between individual agency and social forces, between macro and micro level influences on individual outcomes such as STEM identity. Schools are the setting where children learn about society’s social and cultural forces as their own personal identities evolve.

### **STEM Identity in K-12**

Researchers concur that the most effective time to instill a STEM identity is at an early age as understanding of identity establishes a range and direction for educational choices and trajectories (Aschbacher, et al., 2010; Berry, 2012; Berryman, 1983). With respect to identity formation, focusing on underrepresented minority students in math and

science classrooms in elementary school and high school allows students to see themselves as “doers of science and math” (Varelas et al., 2012, p.323) ultimately influencing the extent to which students can become successful in these fields. From Wenger’s (1998) view, as we go through the process of learning, we are also changing and becoming something new, assimilating into a supportive milieu. The trajectories of underrepresented minority students and understanding how they can or cannot “become” scientists or mathematicians moves beyond learning a discipline to issues of race and opportunity. Lewis (2003) believes that becoming a scientist is a “social process [that]...relies on the judgment and invitation of practicing scientists” (p.371). This social element of learning and the interplay between students and the school setting is of importance to this study.

Berry (2012) studied the principle of identity and learning in a phenomenological study that focused on the math experiences of eight middle school African American boys in an urban setting in California. The researcher established that a positive self-image toward math and school and exposure to rigorous math course act as factors contributing to the success of African American males in school math. The participants were students who had been successful with school math and by ninth grade were in Algebra I. Since students who take their first algebra course before ninth grade are more likely to achieve in higher level math (Berry, 2012), the stories these students had to tell were decisive in identifying ways to foster success. Through the use of interviews, observations and questionnaires, Berry (2012) collected data from the students, their teachers and their parents taking into consideration important academic milestones, and their perceptions about the access into the academic math environment. The findings

supported the previous research that recognition of one's abilities and positive math and academic interaction shaped students' math identities and their persistence. Furthermore, Berry (2012) showed African American students' math identities as strongly correlated to their math success or failure, emphasizing the impact of classroom practices and strategies for resisting racialization.

Nasir (2007) addressed the interrelationship of race with mathematics by situating her study outside the classroom, on the basketball court. Using the sociocultural lens of learning, Nasir viewed identity formation as taking place in everyday settings such as recreation, especially in a culture where basketball is a widespread practice. The participants in the study included 16 middle school basketball players and 18 high school player from an inner-city school district in southern California. The researcher conducted field observations and interviewed the participants on how they calculated their own and other player's competence concluding that when individuals are given a specific task or goal, mathematical computations can be done easily. Nasir's (2007) study confirms that the basketball setting provided students with more opportunities to form identity than a math class does and the racialization of math learning perpetuates these predicaments. This study lends credibility to the importance of the environment in which a student finds themselves and their personal sense of competence.

Others have investigated the role of identity, race and gender in science education (Brickhouse, Lowery & Schultz, 2000; Brickhouse & Potter, 2001; Haun-Frank, 2011; Tan, et al., 2013). The literature considers the barriers to science trajectory, the notion of formulating a science identity and the sociocultural factors that shape career aspirations.

The process of learning science content is complicated by the overlap between social identification and academic learning (Wortham, 2006).

Brickhouse, Lowery and Schultz (2000) considered the issue of race, science and gender and how girls identified themselves in terms of science in four case studies of middle school African American girls in a large, public high school. The school was considered a low-achieving school based on standardized reading scores, 15 % of the population is on free or reduced lunch, and the school was approximately 35 % African American and 65 % Caucasian. The researchers collected various artifacts from the participants such as an autobiography, a journal about their participation in science, observations and interviews with both the students and their science teachers. For each student, a case was written including descriptions of their views supported by other data sources. The students' science identities overlapped in certain ways with other identities such as being a good student, being a leader, or being mechanical. In a similar study, Brickhouse and Potter (2001) examined two girls' science identity in an urban vocational school demonstrating the difficulties that students face in developing scientific competence when they do not develop the identities associated with those practices. The researcher collected similar documentation and also wrote case studies. In both studies (Brickhouse, et al, 2000; Brickhouse & Potter, 2001) the researchers raised the questions of whether the students were encouraged to pursue high-level science classes or they were going to be tracked, the effect that feeling invisible and marginalized had on science identity formation, and how science identities challenged their home community identities.

Haun-Frank (2011) conducted a study of the science career trajectories of fourteen African American students in a Career Academy in a large urban high school using the concepts of space and identity. In this study, the author identified *space* as being both physical and social spaces such as school, home and community and how those spaces interact with an evolving and changing identity. The school was located in a mid-sized urban community with a population of 75 % African American, 14 % White, 6 % Asian and 5 % Hispanic. The students had to apply to attend the program and the process was competitive. The researcher conducted interviews, focus groups and observations focusing on the students' science experiences from their early childhood to the start of the academy. Across the group, the participants describes science experiences as positive, that scientist were people who wanted to discover new things and they envisioned themselves comfortably in these identities. They referred the *spaces* where they experienced science such as zoos, museums, summer camps and church. These informal venues were places of safety as well as learning and stimulation. They also viewed science with altruism, similar to the study conducted by Carlone and Johnson, and they characterized themselves as caregivers who would use science in the service of others. While the females saw science as a way of helping others and their community, the male participants saw science as a means of making them leaders and role model for their community. Haun-Frank's (2011) discussion on gender differences presented a picture of career paths that drew on the concept of *space* from popular media. The findings points to the value of altruistic potential in pursuing and formulating science identities and the potential for spaces of learning outside the classroom.

## **The Development of Science and Math Identity in Higher Education**

Revisiting the metaphor of the river, the “bends” along the way tend to impact and form identity as it is lived through small daily interactions (Berry, 2008) such as the culture of the classroom. Gee’s (2000) reference to being a certain “kind of person” (p.99), a person who is identified by the way they act and what they do in a certain context, lends itself to the principle of a STEM identity. Science and math education researchers (Asbacher et al., 2009; Hazari, Sadler & Sonnert, 2013; Varelas, et al., 2012) employ the identity framework to understand the ebb and flow of science and math identity from high school and beyond, including the impact of choosing majors in the field and persisting in those majors. In scrutinizing these disciplinary identities, it is critical to understand the intersection of race and gender as these professions are stereotypically considered predominately white and male (Roth & Calabrese Barton, 2004).

Professionals in both science and mathematics are subject to stereotypes that are widespread and universal, according to two seminal studies. Chambers (1983) originally developed a test to ascertain at what age children begin to develop stereotypes about certain professions. Using the simple prompt “Draw a scientist” over 4,000 children from three countries depicted a scientist as an old, eccentric, white male in a lab coat wearing glasses. Chambers (1983) contributed to the discourse with the following findings: the stereotypic image that exists for grade school children is even more prevalent among older children and continues to be perpetuated in adults. Drawing on Chambers’ work (1989), Berry and Picker (2000) conducted a similar study in schools in England and the United States called “Draw a mathematician”. This study yielded similar results: a white,



male with glasses who was either balding or with weird hair. Math and science educators express concern that negative images discourage students from an interest in studying these disciplines (Berry & Picker, 2000) by perpetuating a perception of the discipline exclusivity. These studies speak to the dilemma of the underrepresentation of minority students in these fields. While addressing the achievement gap, the “identity gap” (Tan, Calabrese Barton, Kang, & O’Neill, 2013, p.1144) has been overlooked. Schools influence access to math and science by acting as “reproduction cycles of the community” (Lave & Wenger, 1991, p. 98) where students are invited into the community of educated individuals interested in science and learning.

### **The Development of STEM Identity: Tensions and Challenges**

Existing literature provides accounts of factors that influence the attainment of STEM careers for underrepresented minority graduate and undergraduate students. The difficulties in participation and retention in these disciplines disclose the tensions of building a discipline identity that is supportive of a career trajectory. Lave and Wenger (1991) emphasize how the creation of a particular identity is central when entering a new community of practice, locating identity at the point of intersection between the individual and social forces (Malone & Barabino, 2008).

Considering the issue of race and science, Carlone and Johnson (2007) studied science identity in an ethnographic study as it applied to women of color at a large public university. There were 15 participants recruited from an academic enrichment program for underrepresented minority students who identified themselves as *women of color*. The research was guided by a science identity model with three components: competence, performance and recognition in science. Fourteen of the participants went on to graduate

school in science related fields and pursued science related careers. The researchers conducted ethnographic interviews and followed up with email interviews focusing on the reasons they wanted to persist in science, how they perceived themselves as science students and how did their ethnicity shape their experiences.

Carlone and Johnson (2007) used this study as a springboard for their development of a model of science identity. Their results indicated that for underrepresented minority students science recognition in formal setting, such as conferences, was difficult for the participants given the “historical and prototypical notions of a scientist” (p.1207). Identifying recognition as significant in science persistence, science identity themes emerged as follows: research scientist, altruistic scientist, and disrupted scientist. In each case, recognition played a role in how they identified themselves. In the case of the research scientist, those participants saw themselves as engaged in the laboratory culture of science, lab work acting as an apprenticeship for their future. Women in the altruistic scientist category saw themselves as pursuing science to achieve goals that had an interest in helping humanity and not necessarily in the nature of science itself. Their long term goals of altruism dictated their course of study, such as medicine or teaching, reflecting the need to give back to society. In the last category, the disrupted scientist, these students reported feelings of alienation and negative recognition throughout their university experiences.

This research confirms that experiences in a science community, whether in a classroom or a specific department, can create constraints for certain individuals that influence their overall persistence in STEM related fields. Daily interactions and occurrences impact pathways when the individuals are drawn and recognized in their

community of practice (Lave & Wenger, 1991) or are not recognized and excluded. An environment, such as the laboratory culture that Carlone and Johnson (2007) describe, is a place where an individual is learning and transforming at the same time, so how that process is supported and encouraged is critical (Cobb, 2004). As new identities are constructed through new knowledge, there is an expectation that a shift takes place in one's position and status (Varelas et al., 2012). This change in their status and their identity contributes to their overall success as they are recognized in particular ways (Gee, 1999).

Considering science identity early in one's college careers, Hazari, Sadler and Sonnert (2013) examined disciplinary identities among college students in STEM fields by comparing the self-perceptions of the participants across the fields of biology, chemistry and physics and the differences of those perceptions among groups according to race, gender and ethnicity. The data for this study drew from the Persistence Research in Science and Engineering Project (PRISE) funded by the National Science Foundation (NSF) whose focus is to identify high school factors that influence student persistence in STEM disciplines in the transition from high school to college (Hazari et al., 2013). The quantitative study collected 7,505 surveys from students in 40 colleges and universities across the United States whose respondents were 49 % female, 44 % male with 7 % not reporting their gender. For race, the respondents were 67 % Caucasian, 14 % Hispanic, and 8 % African American. The focal question of the survey was: "Do you see yourself as a biology/chemistry/physics person", and specific science identities emerged as a central theme. The results of the study were as follows: a) college students have a low self-perception with respect to science b) male perception of a physics identity was far

greater than female, especially among Caucasian males c) Hispanic females had the weakest science identity and d) underrepresented minority students who intended to pursue a STEM career did not strongly identify with biology, chemistry or physics (Hazari, et al., 2013). The results document an overall low science identity among college students in general, as well as underrepresented minority students who had intended to be STEM majors. Both studies (Carlone & Johnson, 2007, Hazari, et al, 2013) produced an important finding about how disciplinary identity acts as a go-between individual agency and established expectations. As students move through the process of learning and becoming, identities influence opportunities to learn (Vareles et al., 2012).

Malone and Barabino (2008) incorporated identity and science in a qualitative study that was conducted at a large research university drawing from graduate students in science and engineering. There were 24 participants from underrepresented minority groups who all worked in laboratory settings. Fifteen participants were individually interviewed and 19 participated in several focus groups targeting the tensions underrepresented minority students face in a predominately white school in the context of the laboratory setting. The extensive interviews yielded the following themes: invisibility, marginalization, under evaluation/recognition and racialization in terms of identity formation (Marlone & Barabino, 2008). Similar to Carlone and Johnson's (2007) study, the act of recognition had a strong connection to identity formation in the scientific community, that recognition is a symbolic way of being accepted into a new learning community. "Being invisible" (Marlone & Barabino, 2008, p.497) had the effect on individuals of being excluded, and left outside of important networking that could provide opportunities for future access and research. The narratives in this study

disclosed that the issue of race in the scientific community presents a problem for students as they grapple with their identity formation and acceptance into an academic community. Thus, the process of forming a scientific identity requires individual agency combined with participants in the relevant community to reconfirm those outcomes for the students who are entering the field. The research on a discipline identity during undergraduate and graduate years demonstrates how tenuous that identity can be and how easily external factors can disturb one's goals.

### **Summary of the Literature**

This section addresses how underrepresented minority students can be encouraged or discouraged in K-16 settings in terms of pursuing a STEM identity and how social expectations impact their performance in these fields. The review of the literature indicates a range of experiences for underrepresented minority students in STEM fields providing a perspective on the strength and weakness of a STEM *pipeline* and perceptions of access to a STEM identity. There is a plethora of studies employing large data sets that aim to predict matriculation and persistence of underrepresented minority students in STEM fields as well as studies of STEM identity formation at the elementary school level and at the college level. However, after a review of the literature on underrepresented minority students in STEM fields and STEM identity, none were found on the sociocultural factors that influence STEM majors and the STEM identity formation trajectory from high school to a STEM college.

## CHAPTER THREE

### METHODOLOGY

The purpose of this hermeneutic phenomenological study is to generate an understanding of the lived experiences of African American students attending a STEM Honors college at a public HBCU. Phenomenology recognizes that human are “situated” (Chesla, 1995, p.66) in the environment where they have grown up in, which is a complicated web of awareness and insight about one’s surroundings, unspoken rules of how to behave, and a specific time and place in history. As the educational experiences and processes of these students are imbedded in their stories and comprehension of their milieu, phenomenology is an appropriate choice for analysis. This study seeks to generate an understanding the social construction of identity and race that reflect the present time and place of pursuing a STEM major. The goal of this research is to derive the “essences” (Patton, 1990, p.106) of what a group of students experienced to lead them down this path by studying their pre-college experiences and their experiences attending a STEM HBCU college. Moustakas identifies (1994) an intrinsic part of understanding lived experiences as determining “what an experience means for persons who had the experience” (p.13) and then using those experiences to derive general meanings.

#### **Review of the Research Questions**

In this unique context of a STEM Honors College at a HBCU, this hermeneutic phenomenological study will examine the following research questions. The overarching research question was: How did African American students at a STEM Honors College at a public HBCU develop and incorporate a STEM identity from high school to their undergraduate years? The specific research questions were as follows:

1. What is essential about being a STEM major?
2. What experiences and contexts did they attribute to constructing a STEM identity?
3. How did they experience and negotiate their other social identities with a STEM identity?

### **Phenomenology Research Design**

Edward Husserl (1859-1935) is considered the modern theorist who formalized phenomenology as a research design to understand the social and emotional toll of World War I on the European population (Hays & Singh, 2012). Since Husserl, phenomenology has been employed in a number of divergent disciplines such as philosophy, psychology, literature, education and sociology (Groenewald, 2004). In spite of its varied application and modification, there are consistent precepts of the design that are applied to this study: lived experience, essence and life world (Cresswell, 1998). Phenomenologists seek to understand the day-to-day interactions and perceptions of the participants' world, making the terms *lifeworld* and *lived experiences* dependent on each other (Van Maren, 1990). By gathering data about the participants' lifeworld and lived experiences, the researcher can begin to construct an understanding of the *essence* of those lived experiences. Cresswell (1998) identified the goal of phenomenology as reducing the data to a description of the experiences that is typical of all participants in a study; thus, essence means what is the most essential meaning for a particular context (Giorgi, 2009). Phenomenology as a methodology allowed for the conceptualization of the unique experiences of the students in this study and their understandings of those experiences in their environments.

This research problem was best suited for this design because it is a form of research that seeks to understand common or shared experiences of the phenomenon (Cresswell, 1998) of developing a STEM identity and pursuing a STEM career. Each individual had their own version of a pipeline with the end goal, to major in a STEM discipline, being the same among the participants. According to Patton (2002), the researcher must collect data about a particular phenomenon from the participants to understand “how they perceive it, feel about it, judge it, remember it, make sense of it and talk about it with other” (p.104). Using phenomenology as a design, I sought to uncover and understand from the students’ point of view their day-to-day experiences. Since phenomenological reflection is “retrospective” (Van Maren, 1990, p.10), this study asked the participants to recall experiences from their past to the present that they attributed to their trajectories.

Tapping into the phenomenological sense of lifeworld as a source of lived experiences, Van Maren (1990) recommends four existentials, or what he calls “fundamental worldlife themes” (p.101), to serve as a useful guide in the research process. Researchers have operationalized Van Maren’s existentials to explore lived experiences in health and nursing (Rich, et al, 2013), as well as in education (Kirova, 2003). Van Maren (1990) characterizes *lived time* as the “temporal dimensions of past, present and future” (Van Maren, 1990, p.104) making time a suitable measure to plot a student’s trajectory, merging foreground and background experiences. *Lived space* recognizes that places can transmit social standards and customs (Van Maren, 1990) particularly an academic community such as science where interactions are governed and mediated by long held rules and norms (Roth & Barton, 2004). As this study takes place



at a HBCU, the “place” takes on special significance historically and socio-culturally. *Lived body*, considers how we are present in the world through our bodies (Rich et al, 2013) allowing a discussion of race and identity. Lastly, *lived relations*, overlap and traverse the other three existentials whereby as students develop academic identities, they cultivate connections to educators, peers and communities that allow them to engage in building community. In the data analysis section of this chapter, I have described how I operationalized these terms in my study.

### **The Context of the Study**

This study takes place at a STEM Honors College at a mid-Atlantic public HBCU in an urban area. According to the university’s website, the Honors STEM College was established in 1985 to address the shortage of minority scientists by producing graduates in the fields of mathematics and applied sciences to transition into professions in industry, government and education. The MASI program is housed within a larger university founded in 1935 as a public state HBCU. According to the university’s website, the university’s population in 2013 was 7,100: 5,911 were full time, 1,455 were part-time. Of those students 6,367 were undergraduates; 733 were graduate students. Demographically, 93 % students were African American, 6 % were Caucasian and the remainder 1 % were classified as other. The MASI program is more selective than the general admission to the university as students are required to enter with a GPA of 3.3 on a 4.0 scale, a combined SAT score of 1500, four units of mathematics and four units of science before entering the program. Once admitted, students must choose an applied science or mathematics major, maintain a “B” average throughout their four years, and participate in two summer research programs. All students are supported by a full four

year scholarship with contributions from the National Physical Science Consortium and others. The scholarship is only available to students who are United States Citizens. Since 1990, the program has graduated 322 students, 50 % of whom have received advanced degrees.

### **Lessons from the Pilot Study**

In the year preceding this dissertation research, I conducted an unpublished pilot study to explore initial information about the feasibility and potential of my research. Five participants were selected for the study using a semi-structured interview protocol. Two of the participants in the pilot study were former students at the high school where I have taught for 20 years. These two participants were instrumental in putting me in contact with additional students in the program. From the data analysis of the pilot, several themes emerged that piqued my interest in pursuing this topic further.

**Lesson #1: Research design.** For the pilot, I employed a phenomenological methodology at a state public HBCU with a STEM Honors college within the confines of the larger university. As the theory of phenomenology as a methodology recognizes that objective truth is imbedded in the “events of daily life” (Van Den Berg, 1955, p.54), it was deemed as an appropriate approach to the study of students and the processes of deciding on a course of study. The impetus of this study was to generate an understanding of the experiences of students who applied to this program and how their STEM aspirations were supported and encouraged. In the pilot study, the research focused on the following question: What factors did African American students perceive as critical when they chose to attend a STEM Honors program at a HBCU? To guide my interview protocol and data analysis I used the Social Capital Theory (Bourdieu, 1986; Coleman,

1988; Putman, 2000) as the overarching conceptual framework for the study focusing on the impact of networks and norms and how access to those resources can facilitate STEM aspirations in African American students pursuing STEM majors at a STEM HBCU Honors College.

Findings from the pilot study confirmed the effectiveness of phenomenology as a methodology to explore lived experiences of underrepresented minority students as STEM majors in the MASI program. It underscores the essential meaning of a phenomenon and the lived experiences of participants and allowed me as the researcher to widen my scope. In the current study, I also newly added the Van Maren's (1990) phenomenological lifeworld existentials and highlighted Lave and Wenger's theory on identity development in communities of practices as a guide for data analysis. In doing so, I revised the interview questions making them more open-ended and focused on being in the present, and looking at their lived experiences retrospectively.

**Lesson # 2: Preliminary findings.** At the completion of the pilot study, several themes emerged. First, educational environments that stimulate a STEM interest during pre-college years positively influenced students when choosing a college major (Rask, 2010; Subotnik, et al., 2010) Researchers (Stanton-Salazar, Vasquez, & Mehan, 2000; Lewis-Charp, Yu, & Friedlaender, 2004; Concha, 2007) confirm that school programs promoting socialization into an academic and career cultures increase access to social capital and reinforce college-going norms for underrepresented minority students. The participants cited the experience of attending a medical career program, visiting medical colleges, working in labs, and handling cadavers as having significant impact on capturing their interest in the health sciences. Students recognized these opportunities as

relevant and valuable pre-requisites guiding their aspirations to study harder and commit to their goals.

Further, the participants frequently mentioned the importance of teachers, guidance counselors and community members who provided support and resources that enhanced their access to STEM social capital by expanding their information networks. Social Capital theorists (Stanton-Salazer, 1997; Museus & Neville, 2012) assert that institutional agents who are committed to the success of underrepresented minority students can link those students to important information and opportunities. Penual and Riel (2007) stressed certain traits about networks: a) the significance of who was in your network and b) getting help outside one's immediate network is valuable if the source has expertise. Students in this study reported examples of both these interactions and the value those interactions had in their STEM pursuits.

Findings from the pilot study suggest that for STEM majors, the influence of pre-college programs and their mentors including teachers, guidance counselors and community members were significant in formulating their earlier interest in STEM programs. However, these findings also indicate that there was more to uncover about the essence of underrepresented minority students pursuing a STEM discipline. For instance, given that this study focuses on the identity development for STEM majors at HBCU, HBCU as a context of these students' STEM identity formation appeared to need more attention. Furthermore, I realized that the nuances of race and the perceptions of underrepresented minority students in STEM disciplines were not thoroughly explored in the pilot. Taking advantage of the flexibility and the suitability of phenomenology for

uncovering lived experiences, I expanded the study by adding the third research question: How did they experience and negotiate their other social identities with a STEM identity?

### **The Current Study**

Shank and Vilella (2004) likened qualitative research to using a lantern to “illuminate dark areas” (p.48) that were previously unclear and ambiguous to us as researchers. In the same way, the themes that emerged from the pilot study urged me to further examine the experiences of African American students transitioning from high school to college in STEM fields and probe the lived experiences of the participants in relation to the phenomena “for any phenomenon, in the empirical world, there is much remaining below the surface of current awareness” (Shank & Vilella, 2004, p.48). Van Den Berg (1955) maintained that “all phenomenology depends on introspection” (p. 90), thus the current study seeks to uncover deeper elements of the phenomenon.

The topics that still required more delving into were the issues of race and identity in the STEM discipline pipeline and how those experiences emerged in their secondary to post-secondary nexus. There are studies that probe the connection between race and discipline identities from elementary school students to university students (Aschbacher, P., Li, E., & Roth, E., 2009; Crisp, G., Nora, A., & Taggart, A., 2009; Berry. R., 2008; Berryman, S., 1983; Brickhouse, N., Lowery, P., & Schultz, K., 2000). As this study aims to address the STEM pipeline from the socio-cultural context of learning, race and discipline identity have been added to the conceptual framework to expand the preliminary research to and widen the potential for a thick description of the lived experiences of the participants.

**Getting Access to the Field.** In order to have access to a different group of students from the pilot study, I contacted the Center for Applied Research at a mid-Atlantic HBCU to complete the procedures of conducting research at this institution. Hays and Singh (2012) use the term *field* to mean “the context where your research takes place” (p.159) and this contact began the process for me. Before I could officially apply for research at this institution, I met with the director of the MASI program and discussed the purpose and steps of my research with her. She interviewed me in March 2014, asked me about the study, and agreed to grant me permission to conduct the research. With her official approval, I then completed an application and submitted a separate IRB (Institutional Review Board) to the HBCU where I would be conducting the research. Similar to the IRB I completed for my institution of higher education, I explained the purpose, the research questions and design, all instruments and data collection procedures and steps for the protection of subjects. I received the official verification letter on April 2014 (Appendix A).

In the process of interviewing with the director, I had already begun to build rapport with her (Hays & Singh, 2012) and she offered to allow me to use the conference room in the MASI building to conduct interviews. I wrote a brief letter (Appendix B) explaining the intent of the research and requesting participants. The director distributed the letter to a numbers of different classes at the MASI program to reach participants who would represent different majors and different points in the program. Within a few days, students began to contact me by email and set up times for the initial interview.

**Sampling Logic.** As this is a phenomenological study, Patton (2002) recommends “sampling to the point of redundancy” (p.246); therefore, following these guidelines, an acceptable sample for this study was seven participants. This is large enough to ensure factors relevant to the research questions are covered without the data being repetitive and when new data does not provide additional significant information. As the researcher, this gave me the opportunity to have a representation of gender, grade level, and background experiences to the point of saturation (Creswell, 2008). Given the specific focus of this study, underrepresented minority students at a STEM Honors college at a HBCU, the participants were selected by a purposeful, criterion based sampling method (Patton, 2002). These students attend a selective program, have maintained a 3.0 and above as well as fulfilled the other requirements for staying in the program, so they will yield the most relevant information (Yin, 2011). Therefore, the criteria included: 1) African American students who are over 18 years old; 2) those who attended public high schools; 3) those who applied for and are presently attending a STEM Honors college at a public HBCU.

**Participants.** There were seven African American students attending the MASI STEM program at a mid-Atlantic HBCU that responded to my request and all seven were selected. The students represented a range of majors and years in the program and met the criteria. Two of the students were seniors, getting ready for graduation. Of the others, three were junior, one was a sophomore and one was a freshman. The participants included three females and four males. They also represented several different majors: three chemistry, two physics, one biology and one computer science. All the students attended public high schools representing a range of communities from rural, to suburban

to urban. All the participants identified themselves as African American. Table 1 provides the overall characteristics of the participants with the pseudonyms they chose for themselves.

Table 1

*Characteristics of the Participants*

	<b>Gender</b>	<b>Race</b>	<b>Year in MASI</b>	<b>Declared Major</b>	<b>Age</b>	<b>Type of High School</b>
<b>Ashley</b>	Female	African-American	Junior	Chemistry	22	Urban
<b>Brianna</b>	Female	African-American	Junior	Physics	21	Suburban
<b>Danielle</b>	Female	African-American	Senior	Biology	22	Rural
<b>Jason</b>	Male	African-American	Junior	Physics	22	Rural
<b>Jorge</b>	Male	African-American	Freshman	Chemistry	19	Suburban
<b>Supreme</b>	Male	African-American	Sophomore	Chemistry	20	Suburban
<b>Precise</b>	Male	African-American	Senior	Computer Science	22	Suburban

**Mini Portraits of Each Participant.** In order to make this research more personal, I have included a mini-portrait of each participant to describe them in greater detail. Some of the information in this section came from what the participants shared with me during interviews. First, the students signed an *Informed Consent* (Appendix C) and then completed the Biographical Survey (Appendix D). Information about their schools came from their high schools websites. Using that information, I was able to research and include particulars about the schools while maintaining their anonymity.

*Ashley.* Ashley is a quiet and studious chemistry major, who is very sincere and passionate about her goal to work for the Center for Disease Control some day. She grew



up in a major metropolitan area and attended a high school whose population was 50 % African American and 50 % Caucasian and other. Her high school had a Medical Magnet program that collaborates with a medical college and she was able to attend classes there and take advantages of the college's many resources. She is finishing her junior year in the MASI program.

**Brianna.** Brianna is very serious physics major and lights up when she discusses some of the work she has done in her research. Her sister, who is also in the MASI program, is a graduating senior who is getting ready to graduate and continue for her Masters' degree. Brianna attended a suburban high school that was predominately Caucasian. Her high school did not offer any special programs but had a variety of AP (advanced placement classes). She is completing her junior year in the program.

**Danielle.** Danielle is a bubbly, out-going biology major who is graduating senior, getting ready to begin her Masters' degree in Food Science. She describes herself as having grown up across from a pig farm in a rural community, an only child raised by a single parent. She attended a rural high school that did not offer too many classes beyond basic ones and her school was about 60 % Caucasian and 38 % African American with a small representation of Hispanic students. In addition to a busy schedule in the MASI program, she tutors in Math and English at an adult learning center. She is moved by the people she comes into contact with, such as an 80 year old man who was determined to complete the requirements for his high school diploma.

**Jason.** Jason is kind and deliberate young man who grew up as one of seven children raised by a single parent in a rural community. He grew up knowing that everyone in the family had to help, which included working part-time and contributing

their earnings to the family's well-being. He is in the middle of the birth order of the seven siblings and the only one up to now who has attended college. Jason went to a large regional high school whose population was predominately African American that offered a general high school curriculum. He is a physics major at the end of his junior year.

*Jose.* Jose is a friendly, outgoing young man with a big smile. He is the only one of the seven participants to initially describe himself as being of mixed race and then provided a caveat. His mother is African American and his father is Puerto Rican; however, he and his sister were adopted and raised by his maternal grandparents. He considers his grandparents his parents. Since his grandparents are African American, out of respect for them, he identifies himself as African American. Although his high school in a suburban area, with a STEM academy in the school, Jose did not attend that part of the school. He is presently completing his freshman year as a chemistry major.

*Precise.* Precise is an intense computer science student and a graduating senior in the MASI program. He sees technology as being a diverse community of creative people who practice problem solving from a different perspective than non-computer students. He went to a suburban high school that was 85 % Caucasian and the academic focus was on seminar classes for the core academic areas. Although the school is recognized nationally as being very successful, there were few offerings in computer science. He found a place for himself in his high school in the anime club with other students who had similar interests.

*Supreme.* Supreme is a confident chemistry major whose dream is to become an anesthesiologist. He is presently completing his sophomore year in the MASI program. His suburban neighborhood high school had an arts magnet program so they did not offer

many classes advanced classes in math and science. He was intent on keeping up with math and science courses to make himself more competitive for college. Starting in his senior year, he took several courses in math and science at the community college. He was frustrated that his high school did not have more challenging opportunities for him. The school's population is approximately half African American, and half Caucasian and other.

### **Data Collection**

To understand the participants' point of view and allow for the meaning of their experiences to unfold, I developed an interview protocol focusing on my research questions. While the protocol addressed the issues of race and STEM identity using semi-structured interviews, I was mindful of the precepts of phenomenology that my participants' experiences ultimately guided and informed the direction of the questions. I began the interviews by reading a script that explained the intent of the study (Appendix E). Following Seidman's (1991) recommendations, my interview questions followed his model for phenomenological interviewing. In this model (Seidman, 1991), the first interview asks the participants to give an overall description of themselves in light of the topic, such as becoming a STEM major. In the second interview, the participant is asked to describe concrete details of their lived experiences. The final phase consisted of open reflections on the meaning of their lived experiences and revisiting the previous two interviews (Appendix F for Interview Protocols).

I conducted these interviews at the MASI program office conference room over a few weeks and audio taped them. The interviews varied in length from 60 to 90 minutes. I hired a transcriber who transcribed the interview verbatim. The transcriber also signed

an agreement to honor the privacy of the participants. The data was merged into one word document for each participant.

After each interview I completed a summary and reflection form (Appendix G) describing the setting and any other elements of the interview that were not captured in the verbal context. Groenewald (2004) strongly recommends incorporating the practice of keeping field notes during the research process to discipline oneself to reflect on the data frequently and systematically. I also noted any additional questions that should be included in the next interview and wrote a summary for myself about the content of our discussion and merging coding categories while memoing. Miles and Huberman (1994) highlight the importance of that memoing process in regard to “building a more integrated understanding of events, processes and interactions” (p.74).

### **Data Analysis**

Data were analyzed using Van Maren’s (1990) four existentials of the lifeworld by a thematic process. Van Maren (1990) recommends to organize the information for a sense of “organic wholeness” (p.168). To begin the analysis process, the researcher must use “emerging themes” (Van Maren, 1990, p.168) as a guide. In doing so, I listened to each interview and read the transcribed data to check for accuracy to immerse myself in the data. Since the lifeworld existential provided a coding framework, I revisited Van Maren’s (1990) work and other studies that operationalized the four existentials (Rich et al, 2014). I defined the four existentials and how they related to this study. By examining the data, I found examples of data from the interview transcripts related to the definitions.

In Table 2, I have summarized the definitions of each existential from Van Maren's (1990) work, including the descriptors of how each term was operationalized for this study with data from the interview transcripts.

Table 2

*Lifeworld Existentials Operationalized*

<i>Lifeworld Existentials</i>	<i>Van Maren's descriptors</i>	<i>Operational definitions for Lived Experiences of STEM students</i>	<i>Examples of Participants' words</i>
Lived Time (Temporality)	Past, present, future; open and beckoning future; a person's life project; a temporal landscape; as one progress to a goal, how one's reinterpret's who they were then & who they are now; expectations	Life history about STEM knowledge & experiences; exploration of new ideas; future aspirations; how those aspirations were enabled	"Better technology can solve problems in the African American community like diabetes, a major problem in the community. If no African Americans are in science, no one's researching the problem." (Jason)
Lived Space (Spatiality)	Felt space; a space can affect how a person feels; one becomes the space they are in; one's world, profession, interests; places transmit values & history	Contexts of learning-inside & outside of a setting; HBCU's as very specific kinds of places; STEM learning contexts as places that transmit values	"The program gave me a chance-it opened my mind to new perspectives about college." (Jose) "The internship last summer made way for me to study biomedical research." (Ashley)
Lived Body (Corporality)	A person's initial contact w/someone is through their physical presence; one's physicality reveals something about themselves	Gap with white & non-white students in STEM professions; race in learning contexts; stereotypes	"It gives you a sense of pride to look around & see people who look like you doing well." (Danielle) "There have been a

<p>Lived Others (Relationality)</p>	<p>Interpersonal space we share w/each other; communal &amp; community life; mutualities between people</p>	<p>Support from educators &amp; wider community encouragement &amp; interactions; recognition &amp; responsiveness from others</p>	<p>few times where it's been 'Oh, there's the black guy doing computers' and it's OK, that's correct but why was the first part even a thing". (Precise)</p> <p>"It's like a really big family. My classmates, we help each other out &amp; spend hours studying together. My professors, they are inside the family as well." (Brianna)</p> <p>"My guidance counselor, we were close. She recommended me for the Governor's summer medical program. Only 150 students were picked from the state-we were all recognized." (Supreme)</p>
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Once I established these definitions, I chose one lifeworld at a time to use as a lens to code each transcript. In this way, I coded each interview four times from a different lens. As I coded each interview, I developed some preliminary codes and revised some codes as I attempted to decipher how the data reflected the phenomenon of underrepresented minority students in STEM programs. Some of the preliminary codes were collapsed into one, such as *early interest in math and science* and *early recognition*

*in math and science.* From the process of collapsing codes into a few that were representative, I developed categories that led to themes. I revised those into themes for each existential considering how the descriptions from the data reflected the themes (Van Maren, 1990). In Table 3, I have included examples of the initial codes, descriptions of those codes and examples from the data. In Table 4, I have included the finalized codes, categories and themes related to each existential. Once I organized my data, I began the writing process looking at the codes, categories and themes from each existentials. Returning to Van Maren (1990), he reiterates that “writing is our method” (p.124), and with the data organized thematically I began to write as writing “discloses reflectively how phenomenological knowledge is held” (p.130).

Table 3

*Initial Codes, Descriptions and Examples of Data*

<b>Initial Code</b>	<b>Description</b>	<b>Example</b>
<b>Lived Time: Early Interest in Math &amp;/or Science</b>	Describe characteristics of curiosity about math and/or science	“I was always curious about how things worked. Took things apart at home.”
<b>Early recognition in math &amp;/or science</b>	Demonstrated aptitude at a young age	“I was tested in 7 <sup>th</sup> grade & started Algebra 1 then.”
<b>Discipline Competence</b>	Belief in one’s own ability to complete tasks, reach goals	“I completed all the higher level courses in my high school in math & science, so I took courses in the community college as a senior.”
<b>Classes that made a difference</b>	Pivotal experiences either w/a teacher or a class	“Regarding science, physics & engineering, I feel like if you put it in front of me, I’ll figure out how to do it.”
<b>Real World Application of</b>	<b>Skills, abilities &amp;</b>	“I went to the summer

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<b>Math and/or Science</b>	understanding of an academic subject	governor's school for science and we took anatomy & physiology. We did dissections, visited hospitals, talked to pathologists."
<b>Moving from knowing to praxis</b>	Hands-on learning opportunities demonstrating value of math &/or science	"I could see a way to combine science and creativity."
<b>A reason for a STEM major</b>	Seeing STEM as a way to make a contribution	"From 10 years old, I wanted to be a doctor, so I felt I had to have a good background in science."
<b>Lived Space: Opening Doors</b>	Reflections on how knowledge translates to career choices	"You have to seize the opportunity if it is given to you."
<b>Uniqueness of program</b>	Special qualities of the program	"This program made me see what I was capable of. If it weren't for this, I'd probably have become an accountant."
<b>Committing to a STEM major</b>	Processes to decide on particular STEM major	"At first, I thought I wanted to major in psychology, but I couldn't if I came here."
<b>Committing to MASI</b>	Passage & movement that generate opportunity-commit to opportunity	"The door was wide open and it had my name on it."
<b>Research/study outside of program</b>	Research opportunities at other universities	"I want to pursue biomedical research and at the Medical college, I actually get to do some of that research."
<b>Effects of Authentic Learning</b>	Invitations to research/work alongside professors; leadership opportunities	"I just found out that the work we did last summer was going to get published."

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<b>Lived Body: Being the “only one”</b>	Reflections of race in higher level classes or organizations	“What I think was worse was that my friend & I were the only black students in the National Honor Society. I literally had to know the other person.”
<b>Successful people of color</b>	Contexts w/STEM role models	“Being here gives you a sense of pride to see people who look like you doing well in science.”
<b>Evaluating external perceptions</b>	How STEM & race are perceived outside of HBCUs	“When you’re out there, coming fr a HBCU, people will frown on you, they’ll assume you don’t learn much. You have to prove them wrong.”
<b>Negotiating race &amp; STEM careers</b>	Coming into contact w/STEM professionals class, program or an organization	“Until one of my internships, I had never actually seen a Black female medical doctor.”
<b>Personal experiences of race</b>	Perceptions of race outside of program	“In this situation, people only saw my race, not my accomplishments.”
<b>Lived Others: HBCU closeness</b>	Social capital within	“People here made me feel like I was part of a family.”
<b>Strength of peer interaction</b>	Peers working together, studying, tutoring, encouraging	“An elite group of African American scientists.”
<b>Sense of community</b>	Feeling of camaraderie, like minded individuals pursuing similar goals	“We live in the same place for four years; we work to help each other.”

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<b>Professional networks</b>	Professors at the university who can open doors to professional opportunities	“He advised me about a graduate program I’d be interested in.”
<b>Research inside of community of practice</b>	Professors include students in program in research opportunities	“He asked me why I hadn’t applied sooner.”
<b>Experiences bring you into STEM community</b>	Practices for professional future	“I presented research to my peers and professors.”

Table 4

*Themes, Categories and Codes*

<b>Themes: Four Existentials</b>	<b>Categories</b>	<b>Codes</b>
<b>Lived time: Aptitude to aspiration</b>	Content self-opening The altruism effect	Early recognition in math & science Pivotal experiences/classes Outside-of-school contexts STEM for social change
<b>Lived space: Opening a portal</b>	Program as a unique place Other places in higher education	Environment of HBCU Historical context of HBCU Deus ex machina of MASI Outside spaces Lesson learned fr outside spaces Bringing it back
<b>Lived body: Tensions between race &amp; a STEM identity</b>	The power of role models Emerging identity	Being only one Kinds of role models Context role models Perceptions inside/outside Crossing borders

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<b>Lived others: Social ties as building blocks to a STEM identity</b>	Relations w/non-familial significant adults Peer-to-peer experiences	HBCU social capital Professional networks Research within MASI Kinship science Peer-to-peer social capital
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### **Reliability and Trustworthiness**

This study employs a qualitative approach using a phenomenological design to better understand the essence of underrepresented minority students' trajectories and experiences in a STEM field. Phenomenological studies strive to reflect as faithfully as possible the lived experiences of the participants' by using their own words (Yin, 2011); therefore, it is incumbent upon the researcher to gather and accurately represent the findings. To strengthen the reliability of this study, I integrated the following strategies. First, member-checking was used to verify the accuracy of interview transcriptions, encouraging participants' to make corrections or additions to the transcripts in order to maximize trustworthiness (Hays & Singh, 2012). Second, I included an audit trail with field notes, timeline, memos and any other documentation that provided "physical evidence" (Hays & Singh, 2012, p. 214) of the research process. Third, I consulted with peers (Yin, 2011) several times who were experienced in the qualitative research process. Seeking peer group feedback can strengthen findings as well as provide valuable suggestions for revisions (Hays & Singh, 2012). I also consulted once a week with my thesis advisor during the coding and writing process.

## **Researcher Subjectivity**

According to some qualitative authors (Hays & Singh, 2012), the researcher should embrace their subjectivity in qualitative research, adding that being close to the research enhances the researcher's insight and should be viewed optimistically. Yin (2011) advises that the researchers should disclose any personal connections and characteristics that could impact the study or that might influence how the participants might act when working with the researcher. Similarly Cresswell (2008) warns that a researcher's personal background might influence their interpretation of the data. I recognize my own subjectivity from two perspectives-personal and professional-and frame my study accordingly.

In the pilot study, three of the five participants were my former students several years hence at the secondary level. Of the seven participants in my present study, only one had been my student in high school. The students in the MASI program are very close, so the students in the pilot study and the students in the present study know each other. All of the participants in the present study had heard of my prior research and knew of me as a local high school teacher. I feel that gave me an advantage since I have a good relationship with my former students and they were excited and forthcoming about being participants in the pilot study. I do not teach a STEM course but instead I teach in the social sciences. Coming from outside the STEM field, I have tried to have few personal or professional preconceived notions about the propensity to a STEM major. But, being inside the school system, gives me credibility as well as access to students' educational experiences. This explanation is both personal and professional.

Expanding on my professional perspective is my own awareness as a teacher in a large urban high school. Over the past few years, more and more of my high ability, competitive African American students are choosing to attend HBCUs. These are students who took honors and advanced placement classes, were in many cases identified as gifted, applied to a number of different schools, and made their decision based on viable choices. As all my students are seniors, I believe I have an important role in promoting post-secondary opportunities. It is from this perspective that I want to learn more from my participants about their choices and the policies and practices that can improve the access and retention of underrepresented students to higher education especially in fields where they are traditionally under-represented.

Lastly, I recognize as a Caucasian female that my participants may view me as an outsider. However, given my previous relationship with some of the students in the MASI program and my long experience as a classroom teacher in a large high school, I do not believe this was a disadvantage. Lareau (2003) expounds on this very issue as a white, middle class researcher. Her argument is as follows: as educators we are all concerned with a broad array of settings that affect the well-being of children, regardless of their gender, race or socio-economic background. As all groups are representative of some diversity, whether they are gender or class or ethnicity, my class and race do not exclude me from understanding the realities of school dynamics. My tenure and respectability as a class room teacher can transcend those concerns.

### **Summary of the Methodology**

A phenomenological approach allows for a deeper understanding of how the participants viewed their lived experiences and the pipeline that led them to their

academic pursuits. Phenomenology lends itself to this study since I am seeking to understand the perception of the participants' experiences through their own stories. By uncovering the essences of their specific lived experiences, I generate an understanding of the structures that enhance or detract from students' developing a STEM identity. In the findings chapter, I present the data thematically by using the lens of the four existentials in the following order: *lived time*, *lived space*, *lived body*, and *lived others*.

## CHAPTER FOUR

### FINDINGS

A kaleidoscope is a perfect metaphor for the findings chapter as a kaleidoscope needs light to see the continuous variations of colors and shapes. In using the lens of the lifeworld existentials to analyze interview data, each existential was highlighted individually, with all the elements dependent on each other. With radiant light and a twist of the cylinder, each existential of the lived experiences of the participants shifts slightly to reveal another facet of an individual's story. This act of shifting the focus provides new combinations, each image adding to what the process of identity building can look like. Van Maren (1990) suggests that the four existentials form a unit that "can be differentiated but not separated" (p. 105), reminding the researcher that these four structures of the lens are interrelated and interwoven in universal experiences. As with the kaleidoscope, I turned the spotlight on one existential after another, comparing each perspective with the previous one while considering a variety of combinations. Looking through a kaleidoscope, I reconstructed the significant experiences that created the pathway of these students to their STEM identities with each new combination of images.

#### **Overview of the Lifeworld of STEM Students**

Four themes emerged that characterize the essence of underrepresented minority students at a STEM program at a HBCU and the bridge to their identity formation: 1) Aptitude to aspiration: "If there are no African Americans in science, who will research diabetes?" (Jason); 2) Opening a portal: "The program opened doors for me, it decided my future." (Jose); 3) Tension between race and a STEM identity: "It is important to see people of color being successful in science." (Ashley); 4) Social ties as building blocks to

a STEM identity: “My professor saw something in me, he encouraged me to go to grad school when I wasn’t sure what I wanted to do.” (Danielle)

Although each existential will be discussed in detail in the data analysis section below supported by the words of the participants, I will briefly highlight some of the findings. For the first existential, *lived time*, the participants described how their trajectories to a STEM major were enhanced by an early interest and recognition in math and science. These learning pathways acted as a catalyst to their career interests and the potential of their imagined future identities. As this researcher is concerned with experiences and contexts that build a bridge from high school to a STEM College, I considered what brought these students to this point in time. For the second existential, *lived space*, the students reported how their commitments to STEM pathways were based on the particular place where they were pursuing their degrees. Not only did this space provide them with financial support, but obliged them to a non-negotiable commitment of a STEM major from the beginning of their college matriculation. The program and the opportunity acted as a *deus ex machina*, a literary device where a problem is resolved in a story by an unexpected intervention (Hess, 2013). The problem for these students was how to pay for college and what to study; the intervention was the offer of a contract to attend the program and a commit to a course of study. For the next existential, *lived body*, the participants gave examples of race and identity in their STEM and academic pathways that were both struggles and conundrums in their educational processes. The students talked about the lack of role models in STEM fields as well as their personal goals for increasing the number of African Americans in STEM fields. For the final existential, *lived others*, the participants discussed people who were prominent in their



lives from the teachers who led them to recognize their strengths to their professors who opened doors to research and graduate school opportunities.

### **Lived Time: Aptitude to Aspiration**

Witz (2000) contends that when a student develops a strong relationship to an academic discipline, a “self-opening” (p.10) occurs facilitating a deeper understanding of how this knowledge guides one toward a particular direction and inspiration in life. Kozoll and Osborne (2004) make the case that self-opening contributes to one’s personal growth and connectivity to the subject matter, especially in STEM fields. If students can connect with a discipline early in their academic lives, the values they develop toward that discipline guide their choices later on as they begin to envision who they will become. Elements of time make sense when considering a student’s trajectory in terms of what the future holds for them, how they are situated currently to partake of those possibilities and what they have done in the past to be prepared for an upcoming opportunity.

At the beginning of this study, each participant was at a different point in the program. In spite of the difference along the continuum of their studies, they were all asked to reflect back to high school as the entry point to how they saw themselves in the past and how they see themselves in the future. This starting point provided a baseline for understanding the sequence of rigorous content and the building of early STEM capacity. As they interpret and reinterpret themselves over time, they orient themselves to the opening of their future careers through their course of study.

**Content matters.** The theme of “aptitude to aspiration” emerged in this study when the participants were asked to reflect on experiences and contexts that shaped their propensity and trajectory to STEM fields. Two categories of this theme were: content self-opening and the altruism effect. In the interviews with the participants, several students reflected Witz’s (2000) concept of “self-opening” as students described being engaged in STEM content, and encountering pathways and opportunities that built their competence and aptitude. These experiences and pathways furthered their knowledge growth but also allowed them to see career opportunities associated with STEM capacity building.

Jose discusses time as being critical in his self-opening to math and science. Through routine standardized testing, he was recognized as having an aptitude in math from middle school. Based on those assessments, he was placed in a high school level math class:

I was only one of fifteen students to get into Algebra 1 in the seventh grade.

That’s how I was able to move ahead and take Calculus as a junior. I was the youngest in my class.

For Jose, being chosen and guided to higher level math was a source of pride that also opened him to other opportunities. He was unique in describing this recognition with a sense of pride. He saw his math skills as pivotal in leading him to his academic pursuits:

Now, I love math. Numbers-it gets hard but I like the challenge. I’m chemistry major and will have a minor in mathematics. You take two extra math classes and now you have a minor.

For Jose, relations with high school educators were indispensable in continuing his STEM pathway. His AP Calculus teacher gave him the recognition that he felt he did not get elsewhere. He describes it as follows:

My AP Calc teacher saw something in me that I didn't see in myself. It was so moving to me to know that someone else pays attention to you as a person. I felt so lost in that class, but she noticed potential I didn't know I had. She made me keep up with the assignments, maintain my grades-she made me realize that if I put my mind to something, I can do it.

The academic encouragement that Jose received from his Calculus teacher opened the pathway to math success prior to college but also established a strong tie to the academic information. He looked on the subject favorably because of the praise and reinforcement from his teacher. Jose carried this praise with him, reminding himself of accomplishing something difficult like Calculus. His teacher's encouragement also illustrated the importance of norms for academic success since he was able to see the results of his hard work in math.

Supreme tells a parallel story. He started showing strength in math in the fifth and sixth grade, competing with his friends to see who could "out do" the other. He moved ahead to Calculus in high school as Jose did, however, he wanted more. As his high school did not offer the next level of Calculus or AP Chemistry, he applied for a dual enrollment program that provided high school students with access to community college classes. In this program, he took the next level of Calculus, as well as college level chemistry in the second semester of his senior year in addition to completing his

other high school required courses. Supreme did not find being in a community college setting with older students the least daunting:

I already knew what I was doing in the lab and stuff like that. So I fit in easily. And it gives you more independence, like; you learn how you are going to behave in college because no one is following behind you.

Even before officially starting college.

Supreme demonstrated self-efficacy in choosing a more challenging pathway and pursuing it earnestly, knowing it still counted toward his high school graduation requirements and his final grade point average.

In *The Toolbox Revisited*, a study published by the U.S. Department of Education, Adelman (2006) evaluates the paths to degree completion from high school to college. He contends a rigorous high school academic curriculum, that includes higher level mathematics and science courses, had the most positive impact on degree completion by race/ethnicity, closing the “gap” for many students. So important is academic preparation for college success that Adelman (2006) strongly recommends “the first year of college has to begin in high school (p.108).” Jose and Supreme’s stories verify Adelman’s suggestion. By developing a pre-disposition to a course of study, their interests in STEM fields steered their actions. For Supreme, knowing early on that he wanted to study medicine provided him the impetus for pursuing opportunities. For Jose, he saw his love of math and chemistry as a springboard into a teaching career in a STEM field.

Likewise for Brianna and Jason, a high school course was a pivotal experience in dictating their interests and a future college major. Both students are juniors, physics majors and each other’s “study buddy” in the program. In our second interview, I asked

Jason to reflect on his trajectory as physics major. He attended a large high school in a rural community and regrets that he never had anyone to push him, “it wasn’t like I had a mentor, or anything.” He made good grades, stayed out of trouble but “no one encouraged me to take AP or higher level classes.” He always had a natural scientific curiosity about how things work, but it wasn’t until he took an engineering class that he could see how he would connect to the subject matter:

The reverse engineering project that we had to do, that’s what did it for me, things like that, being in that class, I started falling in love with things like that. Taking things apart, designing them back together in a computer program. You started with a problem on paper, you solve it on paper, from there you solve it on the computer and then you build a circuit. That was it-I was shaped. Molded to do this science thing.

The course fulfilled his mechanical interest as well as his interest in how math could be applied in the real world in a tangible and meaningful way. Math was a subject he was good in but he described this course as being a turning point for him. The teacher, retired from the Air Force, regaled students with exciting stories of building sensors on jet airplanes. He attributes this class to helping steer him toward science, starting off as an engineering major and later deciding on physics.

Brianna tells a similar story. She is one of only two females in the program majoring in physics. She took several AP classes in high school such as English, U.S. History, and Biology. The highest level math course she took was Pre-Calculus, which she felt put her at a disadvantage when she was a freshman in college. Since most students already had Calculus, she felt she was playing catch up in the beginning.

Looking back on her pathway, she decided to pursue a degree in a STEM field even before she started applying to colleges. It wasn't until she took high school physics classes that she knew that was what she wanted to pursue:

If I hadn't taken that class, I never would have done this major. We did an overview of introductory classical mechanics. And so, that, really interested me. I remember watching an episode of Full House and they had an egg and the Twinkie and tried to make it to the egg without cracking. And that just always interested me and then we did that same demonstration in my high school physics class. I saw that science was the answer to many of my questions.

In these classes, the participants describe being stimulated by a classes and how those experiences brought about a conscious shift in their thinking and plans about their future.

On the other hand, Precise remembers his high school experiences differently. His interest and tinkering with electronics started at a very young age, however there was little in his high school to capture his interest. As he tells it:

I am drawing a blank on anything that was extremely influential during my school years in terms of my technical and science education. We did cancel some computer science classes at some point; robotics was out of the question.

His high school emphasized the study of the classics and the humanities which left a "computer guy" quite underwhelmed. His saving grace was one Computer Science class where students learned programming languages such as JAVA and C++. Although it was "pretty good to have that much" and he liked the teacher, she was unprepared for the task and was not the best at making sure "it was completely taught to us." Instead it was an occasion for students who were knowledgeable and interested to step up and teach each

other. Precise saw this as a forum for computer science stereotypes, “the nerdies, the nerds”, as he described himself and his friends, to gather and share new ideas. His high school also had an anime club that met once a week where those same students from his computer class would get together, watch anime, and talk about “current technology”. He cultivated a circle of friends that maintained his enthusiasm:

I think some of the nerdiness of being in the anime club and being with some of those alter-culture types-it keeps you up. You wanted to know about the latest innovations-you wanted to talk with your friends about it. So keeping up with those guys kept me up with technology.

Jose, Supreme, Brianna and Jason spoke about how a high school class served as catalyst to their interests in choosing a STEM major. Although Precise felt his needs were not adequately met within the formal setting of his high school, there was still a structure in place enabling his STEM identity. Likewise, Ashley and Danielle reported pivotal experiences related to their content interests that nurtured them along their pathways.

In the summer before her freshman year in college, Ashley attended the required summer bridge program for all STEM majors. Although she initially declared herself as a biology major, during those summer sessions she was doing really well in Chemistry. By the time she was half-way through her first semester, she realized:

I can't be a biology major-I don't even like biology. I really like chemistry, and the funny thing is Ms. Mullen recognized that in me. Before graduation, I went & talked to her about my plans and she asked me, why not chemistry?

She thought back about her experiences in AP Chemistry and her interchange with that teacher when she decided to switch majors:

When compared to biology, I realized I really liked chemistry. Chemistry is everything, it's not that difficult and it challenges you as much more. I don't think I would have realized how much I really liked chemistry if I hadn't taken AP Chemistry and probably would have taken a different path.

When Danielle was in high school, she felt her teachers were pushing her toward english and history since she did well in those classes. Even though Daniellc decided on majoring in biology, it was her experience in an Honors Chemistry class that opened her eyes to studying science. As a youngster, she liked mixing things and experimenting at home so she found her high school Honors Chemistry class very stimulating, especially a particular class project. The "Chemistry Fair" was an end-of-year culminating activity whereby high school students prepared, demonstrated and taught a chemistry lesson to elementary school students:

Although I objected to it at first, when I started working on it, I realized I could see myself doing this. I became conscious that I liked talking to other people about science; I liked doing this because I saw it as a way to use your creativity with science.

Danielle tacitly recognized how high school science classes had influenced her when I asked her to think about how she arrived at her major:

When I started in the program, I was considering going to medical school so engineering and physics didn't seem to fit that plan. Plus, I had never taken a drop of engineering or physics in high school, so I knew nothing about them. Since those were out for me-it was between biology and chemistry. I felt with bio you get a little bit of everything-botany, zoology.



With the exception of Precise, most of the students reported experiences of engagement with content matter in their high school years that were pivotal in steering them to a STEM fields. Students who are meaningfully connected to discipline knowledge can be inspired to a long term understanding of the subject matter and find a place for themselves in that field. In what Hoover (2004) describes as the “highways and byways on the path to identity” (p.102), competence and ability combined with support have important implications. Through interactions over time, an individual’s identity progresses as affiliations with the discipline are strengthened.

**Outside-of-school learning contexts.** For some participants, a sub-theme to content self-opening was outside-of-school learning contexts. Although Jason and Brianna described their physics classes as offering real world applications of math and science, in their pre-college years neither student participated in other authentic learning experiences in STEM fields outside of school. The same was true for Jose and Danielle. These four students did not belong to any science clubs, nor did they attend any STEM related camps, magnet schools or enrichment programs. The other three participants reported some interesting outside-of-school learning contexts that were central in building their confidence and motivation in their chosen fields.

Ashley attended a large high school in an urban area with a Medical Specialty Magnet Program. Interested students had to apply in the 8<sup>th</sup> grade, collect recommendations and transcripts, and attend an interview. Based on the composite score of all those factors, 50 students citywide were admitted every year. Ashley completed the process with the help and advice of her middle school counselor. She remembers back on the interview, being so nervous and shy that she looked down at her lap during the whole

time. In spite of her shyness, she was accepted. For the next four years, Ashley took the required courses for an Honors graduate at her home school in addition to being transported every other day to the medical school in her community. In that program, outside the walls of her high school, she donned a lab coat, worked with resident doctors and physician assistants in state-of-the-art laboratories, and observed open heart surgery from the surgery theater. In retrospect, she asserts how key that program was to her trajectory since she returned to that same medical school as a researcher in biomedicine during her most recent summer internship.

Unlike Ashley, the magnet school at Supreme's home school was for the visual arts. Although he took as many higher level math and science courses as available, there was no long-term program comparable to Ashley's experience. Instead, he was selected by his guidance counselor to attend the state Governor's School for Science and Technology during the summer between his junior and senior year. Only 150 students representing the state are selected each year to attend this month long residential program at a university. Supreme describes his summer activities:

We got to dissect a fetal pig, visited hospitals, went to a vet's office and looked at horse cells and how they got the cells. At the hospital, we went to see organs and stuff like that. We also took human anatomy and physiology.

Although Supreme always dreamed of being a doctor, this experience "solidified it" for him. Even though Ashley and Supreme's programs differed in length of time, their participation exemplified the interplay between students and structures and how these activities can enhance career possibilities. These kinds of experiences are important in

identity formation, especially during adolescence, when individuals look for ways to match personal attributes with interests (Kroger, 2004).

As Precise attended a high school that did not offer too many study options for “technology types”, outside-of-school programs took on great significance for him. Between his personal motivation and his parental support, Precise located and attended several summer computer science programs. He credits his parents:

My parents saw it was something important for me to be able to have a lot of opportunities over the summers. And for that, I guess I was very lucky to be able to have those. I think for one of them, my parents used their tax refund check. The way they put it to me was “I guess we’re not getting our refund, you’d better do well.” Congratulations.

A two week program at Villanova University was particularly impressive. High school students were paired with undergraduates and allowed to work on a project of their choosing such as making a video, a video game, or a video game design using computer languages like C++ or JAVA. Precise appreciated the access to quality technological resources but also to the relationships he built with other students:

So, it was interesting to have those connections, especially because you could bond with other people who were doing the same kinds of things that you were doing and who had the same interests you did.

Precise attended several other programs: one at Howard University and the other at the University of Georgia. Howard University offered a three week residential summer program titled Minority Science and Engineering Improvement Program (MSEIP) for high school students. Although he ranks it as a valuable opportunity, it didn’t teach him

enough about computer science. The LEEDS (Leadership in Energy and Environmental Design) at Georgia Tech was more impressive for field based experiences:

And that was one where we actually got to work with a lot of different people, like student engineers, student computer scientists, and we ended up making a solar powered refrigerator. We soldered the solar panels ourselves, connected the whole thing and tested it out to make sure it works.

Ashley, Supreme and Precise described the outside-of-school learning contexts that provided them with opportunities to become familiar with concepts, practices and information about their subject domain. These resources acted as a bridge between themselves and other people in their communities of practice (Lave & Wenger). Hull and Greeno (2001) describe a concept called “context of activity” (p.83), a setting where an individual connects with subject specific domain knowledge, activities and other people within that community. As some of their reflections indicated, the out-of-school contexts offered these participants a context of activity as a way to nurture their interests and engage in building identities. The fusion of math and science aptitude with hands-on experiences contributes to the students’ predispositions to STEM fields.

**The altruism effect.** The lifeworld of time is open to many dimensions: the past, how one sees their future, and what is potentially within one’s reach in that future (Van Maren, 1990). Making connections to a subject matter occupies a “formative position” (Kozoll & Osborne, 2004, p.158) for individuals and that connection becomes a source of inspiration for one’s future plans and directions in life. The participants in this study described ways that academic engagement in their past became part of their lifeworld, guiding their choices of study in STEM fields and framing their future aspirations.

From their study of underrepresented minorities women in science, Carlone and Johnson (2007) construct a type of identity they call the “altruistic scientist” (p.1190). In their research, they observed individuals who created definitions for themselves of what it means to be an underrepresented minority female in science and how those definitions enable these individuals to overcome obstacles along the way. The altruistic scientists in the Carlone and Johnson study (2007) saw themselves using science for the greater good of their community and as a vehicle for social justice.

Similarly, the participants in this study also spoke about how they felt it was incumbent on them to “give back”. One example is from Ashley:

We made a timeline in middle school of what your life would be like in 20 years.

I said I wanted to work for the CDC and cure AIDS. In biomedical research, I can do that. I can work for the CDC and still get involved in public health matters and help people. I want to stay involved with people and not be just a lab rat.

Similarly, Danielle tells her story about where she sees her STEM studies taking her.

Initially, she planned on going to medical school after college. Since modifying her plans, she is preparing to enter graduate school for a Master’s in Food Science. Her career goals still embody the altruism she started off with:

Diabetes is a big health issue in the African-American community. Combining my love of science and food seemed to be a good way to give back to my community.

By studying what and how we eat, I feel I can have a greater impact on people’s lives on a day-to-day basis. What do we do everyday? Eat!

Interestingly enough, Jason also brings up the issue of diabetes and science in a broader context:

Diversity in the STEM community helps solve problems. You know, diabetes is a major problem in the African-American community. If there are no African Americans in science, no one's researching that problem; no one's trying to contribute to improve. So, I want to be someone that better mankind using their knowledge. And that's what science does.

For Brianna, she framed her altruism in twofold: teaching and inventing. When she considered the small number of students in physics, she commented:

Maybe the fact that many students are not going into physics is because they don't have a teacher to gear them towards physics or really show them the capabilities it has to offer. So-I'd like to do that. I'd like to be the one that gets them excited. That would be very rewarding.

The promise of research and invention is also attractive. During one of her summer internships in material science, Brianna worked with researchers on innovations in car windshield designs:

I want to work hands-on with new innovative technology something like windshields that will have the directions right on it. Making better cars would improve products. I'd also liked to study energy saving cars. With energy innovations, I want to ensure that we actually remain on earth.

Jose also saw being a STEM major as giving him the opportunity to give back:

I feel like the purpose of life is to leave your legacy. That's why I chose a STEM major, because in the end you can use it in many ways to help people. If I go into pharmacy or forensics, I see that as helping others.

For all the participants with the exception of Precise and Supreme, the altruism effect surfaced out from connecting a STEM major to a career goal, such as research in medicine, food, or products. They saw themselves as using science in some way to better the future.

The role of content knowledge and the transformative potential of a STEM career combined under this theme of aspiration to altruism in lived time. Looking over the past as a way to their future, the participants recognized and were recognized as having a strength in a subject matter discipline. As they pursued this strength more methodically, the subject matter played a role in their subsequent career pathways. By being interested or inspired in a discipline, most of the students saw how they could use this knowledge for a benefit to society as their future takes shape.

### **Lived Space: Opening a Portal**

In transitioning from one existential to another, I turn the cylinder of the kaleidoscope to alter my focus to *lived space*. Like looking through the kaleidoscope, the images are slightly different but the components under consideration are consistent, allowing for the constant comparison of data. In studying these pathways, I paint a long view picture of the influences on the participants' lifeworld following the thematic analysis established in chapter three. As the purpose of this study is pedagogical in nature, the researcher is trying to understand the significance of contexts and relations in the lived world of the participants' educational path. Each of these existentials in tandem with each other will tell the whole story of these students.

For individuals to experience lived time, there must be settings and circumstances within which a person is situated to undergo and be subjected to interactions. These

settings are like a stage where a drama unfolds before the audience. As Van Maren (1990) reminds us, lived space positions the researcher to question how and where we experience our day-to-day lives and what is fundamental about those locations. The theme of “opening a portal” emerged from the data analysis of the participants when turning the lens to lived space. When one enters a portal, we imagine an approach or an entrance to an important site. Gaining access in this way implies an invitation, building expectations. The nature of this invitation is being invited into the program, presented with an incentive to participate. The program’s expectations are rigorous and academically challenging, consequences of the standards of this space and STEM fields. As the participants discussed their respective pathways, two concepts emerged in this theme relating to this idea of opening a portal: the program as a unique place and authentic learning places outside of the program.

**A center of inclusive STEM excellence.** As this study takes place at a HBCU, the “place” takes on a special significance since HBCUs were founded on the principles of “uplifting and empowering” (Albritton, 2012, p.312) the African American community that was historically denied access to higher education. Seeing that the pursuit of higher education is considered a hallmark of the American Dream, more importantly for underrepresented minority students, education embodies the “very essence of citizenship and personhood” (Allen, 2007, p.264). Enveloped within the walls of these historical markers is this STEM program under study, a program housed within a larger university setting. In a study of underrepresented minority students in structured science programs, Hurtado et al (2009) employed the term “inclusive excellence” (p.195) to describe



initiatives that address an underrepresented population in science. It was deemed appropriate to apply to this program.

The university, founded in 1935, was the only HBCU founded during the Depression and was seen by its students as a way to increase their employment opportunities during these difficult economic times (Cabiao, 2014). Presently, the mission statement of the university from the MASI website is:

Through exemplary teaching, scholarship and outreach, the university transforms lives and communities by empowering individuals to maximize their potential, creating life-long learners equipped to be engaged leaders and productive global citizens.

The university's history is subsumed into the broader context of what it means to be a HBCUs. As defined by the Higher Education Act of 1965 a HBCU is:

...any historically black college or university that was established prior to 1964, whose principal mission was, and is, the education of black Americans, and that is accredited by a nationally recognized accrediting agency or association... (HERI, 2010).

By virtue of its location in an HBCU founded in 1935, the program espouses the traditional imperatives of HBCUs, including the additional targeted goal of increasing underrepresented minority students in STEM fields as the program was conceived to address the dearth of minorities in STEM fields. In contrast, other examples of successful STEM programs addressing underrepresented minority students are housed in predominately white institutions (Stolle-McCallister et al., 2011). Researchers underscore the success rate of HBCUs in increasing the number of underrepresented minority

students with bachelor's degrees in STEM fields (Bettez & Suggs, 2012; Kendricks, Nedunuri, & Arment, 2013a) resulting in 41% of STEM degrees among African American students (Baskerville, Berger, Smith, 2008; Kendricks, et al., 2013a). It is against this background that lived space figures strongly in the participants' reflections.

The concepts of *interactional field* and *contextuality* (Abbot, 1997) are apropos in analyzing this existential. Abbot (1997) identifies *field* as a place where time and space overlap, a setting whose context is demarcated by geographical, social, historical and economic factors. Whereas *contextuality* provides the field a "network of intertwined processes" (Abbot, 1997, p.1157), specific influences and resources make it unique. When Bollnow (1964) talks about individuals and their relations to their space, he sees space as providing opportunities to expand one's life adding that individuals are conditioned by their spaces. As a field, the STEM program is both an idea and a physical location bounded by norms and beliefs. For contextuality, it is characterized by context facts that spurred the program's inception and continuation. As the MASI program was created for minority students to matriculate in STEM disciplines, the program represents a space in higher education where students' opportunities are expanded. The program is defined by its geographic location, requirements for admissions, expectations for matriculation, a scholarship and a robust network of alumni, professors and current students interacting in a variety of ways and being conditioned into certain practices and ways of thinking.

In understanding the relevance of spatiality, field and contextuality also apply to the geographic location of the university. The university is located in the mid-Atlantic region of the United States in a southern state. When examining space and sociocultural

factors, the historical background of this institution is germane; until the Civil Rights movement of the 1960s, segregation and Jim Crow laws in the South made it almost impossible for African American students to attend predominately white institutions (Freeman, 2005).

In this context, the program as a portal renders an image of a physical doorway to opportunity as well as a metaphorical opening implying a choice. Students who consider attending are committing to a lifestyle choice, which is being a STEM major. For Jose, this opening was critical to deciding his pathway to Chemistry:

The program was a blessing; it gave me a chance, opened my mind to new perspectives, essentially deciding my future.

As a *deus ex machina*, the possibility of attending this program was an intervention and a solution to a problem highlighting the significance of commitment to a particular field of study. For Jose, this invitation unlocked an opportunity for him that he did not perceive was available to him before this.

While Jose saw the program as an opportunity that opened his mind to other options, Danielle was attracted by the feel and the closeness of the program. During the application process, Danielle interviewed at a small, private college that offered her a substantial scholarship to pursue a STEM major. She was tempted as the school had many attractive features such as being close to home and smaller classes. The STEM program also offered those same features but something special tipped the scales for her:

It was between here and the other school-they both offered me scholarships.

But when I came and interviewed here, they pitched the idea of family to me,

and I can't turn down a family. The other school made me feel like, you're coming here but you're on your own-establish yourself. It is good to be on your own but it is also good to have a shoulder to cry on when you need. At eighteen, I thought I needed it.

By accessing the idea of "family" as an important characteristic of the program, she recognized a connection to the African American community that the other school did not offer her although it was also a small college setting. Similarly, Ashley considered how the program embodied the characteristics of a special and inviting place for studying science:

When I came for the interview, I really saw myself here because the classes were small. And when Dr. McMannus made the presentation to the potential students about the program, I heard about the success rates, numbers of students who majored in different sciences, where they went afterward. I remember thinking, I could see myself here, I can do all this-mentor, internships, study groups. I see myself among other African American science students.

Other students echoed the same remarks. Brianna talked about the program as an "investment" in her, an investment that allowed her to enter as a Physics major:

If I didn't get this scholarship, I would have gone somewhere else. I don't think I would have had the same opportunities somewhere else.

Jose adds this:

If you see an opportunity like this, and you take it, it actually makes you more free. Free from debt, just keep up your grades and your commitment.

Jason was the only one of the seven participants who was not accepted to the program in the spring of his senior year. Instead, he was admitted to the university itself and arrived the summer before his freshman year to attend the Summer Bridge program that all incoming STEM majors are required to attend. He noticed that at certain times some select students were separated from the group to discuss their special program. These actions piqued his interest and curiosity, leading him to find out what the program was about. There were still two scholarships remaining and those would go to students from the Summer Bridge program who met certain criteria such as test scores in math and science. With that information, Jason was determined to be one of those two awarded the scholarship during the summer. Thinking back on how things went for him that summer, he remembers consciously competing, targeting the math and science requirements, staying up late during the evening study sessions. He comments:

It was a door wide open, just calling my name. Getting into the program was one of the happiest days of my life. Now that I'm in my third year, I tell myself everyday that they are paying me to do an important job. And that job is to be the best I can by studying. Not only do they support me financially but academically as well. I love the energy here.

Unlike Jose and Ashley, Jason remarked he was not mentored when he was in high school. He compared that lack of encouragement to how he felt when he came to the summer bridge session for the STEM program:

I just never had anyone push me towards AP or IB, I thought about it but I didn't have a mentor. My guidance counselors weren't trying to push me in that direction. I was making good grades, stayed out of trouble that seemed good

enough.

While Jason did not develop encouraging ties in high school, he was able to access support that enhanced his success when he transitioned into the STEM program. Jason thinks back on the sequence of events that brought him to the place he is now.

That summer, I studied very hard and applied myself. When I got the scholarship, that was something. To have someone recognize you, like the director of the program, and see there's something in you.

In the competition to be awarded the scholarship to the program, Jason's abilities were recognized and this recognition and support essentially launched him into his STEM pathway. Jason's experience demonstrates how resources can lead to developing norms that advance an individual's goal by symbolically welcoming him to participate. The admittance into the program symbolically recognized his potential while inviting him into a network of African American scholars. Jason exuded enthusiasm for his choice and opportunity. While most students were positive about their potential professional expansion, others struggled with the specificity of the commitment and the conditioning required. Supreme, in particular, seemed to be uncertain. Others discussed how they reconciled their initial proclivity to a major with the choices presented to them here.

Supreme described a different perspective. In January of his senior year, he was admitted by early action to a well-known state PWI (Predominately White Institution). He still applied to the HBCU STEM program. When he was admitted, he had to decide quickly otherwise he would have lost the option for the scholarship. Because of the deadline, he felt rushed and constrained. He had not received his financial aid package yet from the PWI and had nothing to compare. He admits that it was hard to pass up the

scholarship but “I’ll always be unsure in the back of my head.” Supreme’s comments point to some discomfoting evidence about the program. He expressed the idea that this was his second choice. He adds that he feels somewhat limited by the program since the curriculum doesn’t allow for flexibility:

In the program, we don’t get a lot of choices as to what we want to take. And I feel that if you’re a scholar, you should be able to see what other things interest you and be able to take other classes. I don’t like that computer science is required for us to take. I’m not going to use computer science but it is in the curriculum.

Jose also mulled over the idea that in order to get the scholarship, he had to commit to a STEM major as he initially wanted to study law in college. When I asked him if he felt he was “forced into a major”, he answered very philosophically:

I don’t see it as being forced into a major but as a compromise. I can do this; I can do the math and science, so why not? Now, I see this program as the backbone of my future by helping me make a choice. It is a degree and I can do anything with a degree.

For Danielle, a biology major getting ready to graduate and head to graduate school, she deliberated about her conundrum as an entering freshman:

When I started college, I thought I wanted to go to medical school and be a doctor. I actually thought psychology would have been a good major for understanding people, how they behave, what makes them tick. But, I couldn’t do that and be in the program. Ultimately, I made the right decision.

Ashley recognized the momentum that this particular space unlocked for her:

In the back of my mind, I knew this chemistry thing was going to be hard and

if it didn't work out, I would major in math, become an accountant and crunch numbers. This is way better!

By becoming a part of this physical space, these participants developed norms and practices over time that were applicable to those disciplines. In their process of STEM identity formation, these students made some choices, which in essence constrained their pathway to a different major. Consequently, those choices located them into a specific context that moved them forward in that field.

**Other places.** Whereas the university and the STEM program represent a static place, lived space also implies movement and fluidity. These participants experienced this dynamic process of back and forth when they left the geographic boundaries of the program during the summer to complete the required internships, and then returned with new ideas and skills in the fall. The landscape of their education in these 'other places' changed as they come into contact with different settings, with a more global population and current practices. The venues described by the participants are similar to Gee's (2000) discussion of a "discourse space" (p.111) where individuals have experiences that influence their trajectories involving "interactions across and among, different groups" (p.119) that contribute to the formation of their Discourse identities.

Brandt (2008) describes "discursive spaces as locations of possibility" (p.718) where students engage in research and discussion with faculty and peers, and where resources are available to students. These spaces allow students to develop their identities and their talents elsewhere and are recognized by others in another setting. While operating in these spaces of peripheral learning, these students are in essence building a "conceptual bridge" (Lave & Wenger, 1991, p.55) to their discipline community. .



Wortham (2006) suggests that researchers must follow a participant's identity formation across different locations and events as a person does not "become" in a single context.

So for Brianna, she was building her identity in science when she attended a program in material science for physics students at a southwestern state university. Being in this summer research internship was an "eye opener" for her because it was a large campus with a diverse population and ample resources. It was also her first time being so far from home, something she was uncomfortable with at first. Brianna described the day-to-day requirements of the research as follows:

After I checked in with my advisor, he would put me in an office to finish up any work from the day before. Then, I'd got to the lab, and what I was doing there was nailing silicone wafers with a silver-alloy deposited on them. I would have to the deposit the silver layers onto the wafers and analyze the results. That would take a day and the next day we'd go to a different lab and run results there and get that information and analyze it and see what is was telling us.

In this experience she found herself in an environment that Lave and Wenger (1991) describe as peripheral learning, where an individual finds an opening or "a way of gaining access to sources for understanding through growing involvement" (P.37).

Ashley shared analogous thoughts on her summer research:

I spent a month on the campus of the state's medical college and I did my research at the Institute for Instructional Biology and Drug Discovery under Dr.Dino. I really liked my research since it was in medicinal chemistry, an interest that I have. We synthesized sulfated chalcones to see if they were potential in

inhibitors of the enzymes of the coagulation cascade. Basically, to see if it would help patients stop clotting.

Both Brianna and Ashley describe these summer research events as empowering them to move on to other accomplishments, especially since they were going to be published with their professors for this research. Ashley talked about what she thought when she found out about herself:

I made me feel really good. I forgot completely that they were working on a publication. Sometimes I thought, "Oh, this is just something for her to do."

But then I found out that they were going to use my data. It made me feel like I was an evolving chemist.

Both Ashley and Brianna were able to grow from these experiences and learn new skills and increase their expertise. Brianna considered how the research influenced her:

When I first got there, I didn't know anything about material science so I had to prepare a lot. By the end, I thought I do understand, I get it. I found out what was available in the field, and how research is done at bigger school. It taught me that if I do the best I can, I can go to those bigger schools for graduate school.

Jason had similar experiences to Ashley and Brianna. He, too, recently found out that his research from last summer was going to be published and he was very excited. He pondered how that research experience changed him as he considered norms and practices in his field:

I had no idea how independent research really is. It's literally you sit down and you just research. You sit there and try to solve a problem, you read a lot. I knew nothing about solar physics so early on, I am sitting there reading about the sun,

things that occur on the sun, reactions and things like that. It was a reality check-I sat down from 8-5 on the computer all day, programming, typing, and downloading images.

Precise's summer research took him at a large state university in the Midwest. As a computer science major, access to practice is an important part of becoming more skillful and staying current. This particular research experience broadened his knowledge but also his confidence:

They treated us like it was an 8 to 5 job but you had autonomy, you had to get your work done. We'd meet with our advisor, and we'd talk about what you were doing, what problems you were having. All the grad students were in there and I would get treated in a similar fashion to them. In the same way, I'd have to get up and say what I have done, what problems I'm having.

As an undergraduate in the summer program, Precise felt valued and on equal footing with the graduate students, being part of the community of practice. He liked being recognized for his work, especially when it was affirming that he was moving in the right direction.

Examining space as an avenue of understanding student trajectories is a worthwhile strategy. Space allowed students to consider the importance of the place where they were matriculating as well as taking their identities to other spaces and experiencing new dimensions of themselves. As these excerpts demonstrate, participation in summer research opportunities was transformative for these participants by broadening their perception of what it meant to be a STEM major. Students were given the opportunity to travel to other parts of the United States, in many cases to larger

universities with many state-of-the-art facilities. These research events became building blocks for their professional interests and identify, giving them a chance to publish and work with students from other parts of the United States as well as other countries. Experiences in other venues and authentic learning afforded the participants opportunities to broaden their professional networks and norms while enhancing their STEM social capital. Now they had connections with professors, graduate students and undergrads in other settings engaging in a larger collective community of science and simulating practices that occur regularly in higher education, both professionally and intellectually. As Lave and Wenger (1991) claim, “changing locations and perspectives are part of actors learning trajectories” (p.36) thus confirming the accounts of these participants that changing locations built their understanding of norms and daily activities of their community.

### **Lived Body: Tension between Race and a STEM Identity**

The kaleidoscope is in motion again moving on to *lived body* as I continue to analyze the lived experiences of the students in this study. In spinning and turning the gears of deliberation, lived body is another layer added to lived time and lived space since one’s experiences take place in the first person. The pieces of the kaleidoscope align with each other, the mirrors reflecting back on each other, forming a symmetric image. Our body is the nucleus of understanding of the lived world; therefore, the body cannot be separated from the time and space where it resides. As experiences accumulate, the body filters new information mediating and reconstructing inbound stimuli. In phenomenology, the term *embodiment* means that our bodies are providing us access to

the world around us, telling us about situations we find ourselves in or expectations made of us, basically the body knowing and understanding what to do (Van Maren, 2007).

In this way, the lived body refers to the meanings the world has attached to one's existence (DeSensi, 1996) through social institutions where "the body both shapes and is shaped by society's" (Williams & Bendelow, 1998, p.209) rules of behavior. When a stranger meets someone for the first time, they meet in the physical landscape they both occupy with all the elements of their autobiographical circumstances and social conventions (Van Maren, 1990). By considering the lived body as an extension of the social world it inhabits, this existential lends itself to the discussion of race in educational institutions in the United States as race has a long history of impacting student opportunities (Allen, 2007). In Jacobson's (1998) extensive study of the evolving concept of race in American history, he asserts that "races are invented categories-designations coined for the purpose of grouping and separating people along lines of presumed difference" (p.4). It is these designations of difference that have historically influenced the course of access to resources for certain groups such as African Americans. The theme throughout Jacobson's (1998) history is that "race is not just a conception; it is also a perception" (p.9).

As this study considered the under representation of minorities in particular professions, race and perceptions of race are important threads that run through these reflections. In analyzing the data from this existential, the theme that emerged was the tension between race and a STEM identity in academic settings. Mutegi (2012) suggests that an area of research requiring more attention is how the sociocultural construction of race impacts STEM outcomes and racial disparity in these fields. He advocates research

that considers how images and expectations may play a role in “supporting or inhibiting African American science performance” (p.95). Cobb (2004) discusses a process called “emerging identity” (p.336) when students are transitioning from “who they are and who they want to become” (p.336) into an enduring identity. In analyzing the transcripts, the participants acknowledged that they struggled with images and expectations of race in STEM fields. Given the codes that came to light from the interviews, I considered two categories of this existential: the power of role models and the process of an emerging identity.

**Being the “only one”.** Malone and Barbino (2008) discuss the term “the only one” (p.489) in their research on the salience of race in STEM education. According to these researchers (Malone & Barbino, 2008), the minority student participants in their study reported feelings of “invisibility, not feeling valued, and isolation or marginalization” (p.488). Given the frequency of these kinds of statements in the focus groups they conducted, Malone and Barbino (2008) questioned the long term influence of these feelings with regards to participation and persistence in STEM fields where African Americans are visibly fewer in numbers. For Kozoll and Osborne (2004), participation in STEM fields is guided by how public education experiences and structures allow minority students to become successful in these settings. The similar theme, “being the only one”, appeared in interviews with students in this study, whether they attended high schools that were predominately Caucasian or predominately African American.

Several students described settings where they were one of a few or the only ones, in certain classes and in organizations. Precise attended a public high school in a suburban area where 12 % of the students were African American. What he remembers

was how he felt when he was inducted into the National Honors Society. He talked about how there were only two African American students in the organization in a school with a population of 1,300 students. He commented:

What I think is worse is that my friend and I were the only black students who were in the National Honors Society. Literally, I had to know the only other person but we also just happened to be good friends.

Along the same line of thinking, Precise remarked about the classes he took as well:

So, I think everyone was complacent like, that's OK, that's our ratio right now, so we should accept it. What seemed to be more of a problem were the higher level classes. General classes, they were horrible in terms of behavior and teachers. But in higher level classes, there were very few of us.

Brianna attended a high school where 14 % of the students were African American and described a similar scenario. There was a difference between who was in the challenging classes and who she sat with during lunch. Her account goes like this:

In physics class, there were only two of us. Then I'd go to lunch and see all my other black friends. There would be 10 or 15 of us at lunch at one time, and when I went to class it would decrease again, to like, three or less.

Ironically, students who went to schools with a greater representation of African American students reported similar experiences, such as Ashley and Jason, who both went to high schools that were over 55 % African American. In spite of this, both students described experiences that were similar to Precise and Brianna's. Ashley describes her experience in AP English class and the medical program classes:

On the first day of class in AP English, I looked around and I thought “oh, I’m the only African American in here”. Also, in my medical program classes, the students that were in the same program, it was a majority Caucasian. We were in most of our classes together from freshman year.

In the same way, Jason experienced something comparable. He talks about the Honors Calculus class he was in:

You didn’t see many African Americans, you just didn’t. I remember there were two African Americans in that class, myself and one other.

Danielle compared how she felt in high school to how she felt in the STEM program she presently attended:

Being the only one, it had always been that way; actually coming here was something new for me. I tried not to let it discourage me in high school, I tried to build relationships with my teachers and a lot of times, they would encourage me.

It was new for me coming here, being in classes with so many African Americans.

The lack of minorities in Danielle’s upper level high school classes extended beyond just how she felt in the classroom:

When I was in high school, my teachers tried to push me in the direction of English and History. There weren’t many people like me in science or math being mentored at my high school.

Feelings of isolation can be powerful and do not nurture students’ potential, especially in challenging academic disciplines. In considering the elements of the lived body and race together, pervasive evidence of surrounding social practices are difficult to ignore.



Although not explicit, this aspect of the participants' lived experiences reflects an isolation or being set apart from other minority students in higher level classes.

**Negotiating perceptions of race and STEM fields.** Erikson (1980) refers to identity formation as an unconscious process, where a young person aspires to emulate an important person in their life and then they begin to build expectations of who and what they can be based on that person. Demonstrating how critical race is in that identity formation process, Jocelyn Elders, the first African American female surgeon general, made a memorable statement about the power of role models. When asked why she didn't aspire to be a doctor as a child she answered, "You can't be what you don't see. I didn't think about being a doctor. I didn't even think about being a clerk in a store—I'd never seen a black clerk in a clothing store" (Dreifus, 1994). The implication of the influence of other individuals for identity formation is clearly that students need to be introduced to viable and relevant career options from their formative years. Almost all the participants shared reflections and tensions of how they reconciled images and expectations of race with their emerging STEM identities during the process of becoming part of their academic community.

In looking for an understanding of the importance of images, Jason presented a paradoxical view about role models for young African Americans:

I think African America males get stuck on sports. Until they realize, I'm not going pro, what else can I do? I guess the icons that they see are winning the touchdown, or beating the buzzer. But there are other icons out there, great African Americans doing great things.

Roles models in sports are numerous for African American students but not as evident in STEM fields while images of students and faculty at HBCUS have a powerful effect as Jason described. Being in a positive, enriching environment with strong role models produced significant results for him this way:

I'm looking at a room full of 100 or so scholars-all African Americans- who have big dreams and it changes you. It makes you want to do more.

He recognized the personal importance of the context to him as an individual interlinked with the community he was becoming a part of:

Today, we had our induction into the National Science Honors Society and being part of something among African American science students in that way is so special to me. It reminds me to say, that we can make it and you can inspire to dream big and go out and get it. Now I am part of an elite group.

Danielle acknowledged the importance of being surrounded with successful African Americans as well as the element of racial pride and community. When she reflected on attending an HBCU, she conveyed that sentiment:

I saw a whole new world that I never saw before. Growing up, the few friends of color that I had were usually just like me. Here it was a new world and it gives you a great sense of pride to see people who look like you that are doing well.

Likewise, Danielle attributed her early interest in studying medicine to her family doctor who provided her with a valued role model. As a child, the only African American doctor she had ever seen was her family pediatrician:

He was the only minority doctor I recall growing up and I wanted to be like him.

There was something about him-caring, personable. He was looked up to by the community and I wanted that same level of respect from the community.

Recently, Danielle's mother gave her a picture she saved that Danielle drew when she was in first grade. She described it as follows:

When I was little, I drew what I wanted to be- a little nurse in a lab coat with a stethoscope. Even from an early age, I knew this is where I'm going.

Similarly, Brianna, who attended a predominately white high school, appreciated the value of role models in her field. She said the following about going to a HBCU:

So, I wanted to go to a HBCU and I'm really glad I did. I went to a school that did not have a large African American population and I wanted to get the feel, especially in science. I wanted to see people who think and look like me.

For Jason, Danielle and Brianna, images of African Americans in STEM fields provided strong expectations for them by confirming the positive nature of seeing African Americans in STEM fields at HBCUs. Jose, however, lamented images and role models in science disseminated by the media that perpetuated an image of science that did not include underrepresented minorities. He saw it this way:

But you have to blame the media because the movies, that's what everyone watches. Who is the face of science? Bill Nye, the science guy. That's what we give our kids. I watched him as a kid and everyone recognizes him. It's how you portray an image to students. You don't see a black scientist in the movies.

This lack of images in a STEM field made it difficult for Jason to see how he could fit in during the first summer research to an out-of-state university research site. He presented his conundrum:

I was the only African American male in the group out of 10 Caucasians. I don't know why but I felt out of place and pressured to succeed. You wonder-am I good enough to compete with these guys?

Over the course of the next few weeks, he became absorbed in his research project. As he developed skills and confidence in his abilities, he came to terms with his uncertainty:

As time went on, I realized, I have my research and the others have theirs. And it was a matter of doing our work. When I realized I was competing against myself, I felt better.

Brianna conceded the double-edged sword of race in STEM fields particularly as an African American female. She saw the benefit of parleying her identities when she applied for the first summer research program:

My advisor called me in and specifically told me to apply because they were looking for African American students in science, especially females.

Although she accepted the fact that her minority status probably gave her priority for getting into the program, in the long run, it didn't matter. Her overall goal was to make sure that her summer experiences provided her with useful skills and experiences as a science student and enhance her resume. When we discussed the fact that there were only 6 or 7 African American students out of 100, she spoke about how she saw that:

If you're reading a paper that is published in a journal, you're not going to see what I am. It is just if you are standing in front of someone do you see the discriminatory aspect of it.

Brianna merged the matter of race and education under the idea of reaching an academic goal such as publishing research which was an important measure of an accomplishment.

Along the same lines, Brianna saw where race could work to her advantage in the professional world. When asked to contemplate if it was a disadvantage being African American in a STEM field, she answered:

I see it as an advantage and a disadvantage. There are some places out there looking for African American women, because they need you and want you. So you're a woman, and you're in science, and on top of that you're black in science.

I mean that's the world out there, it is everywhere. That could be a good thing.

For these students, the key to belonging in a STEM field was to find viable role models either in the community or in the HBCU they attended. Although acknowledging a dearth of professional images in the media, they discussed their determination in proving their own capabilities. By rationalizing their thinking, some students even found ways to use race to their advantage.

**Crossing borders outside the HBCU.** The participants in this study recognized that in order to advance in a STEM field, graduate school was an important part of their future. As they contemplated where they wanted to go in their studies beyond the program and other STEM opportunities, a number of students referenced a dichotomy between the STEM world inside the HBCU program and the world outside the program. Moving from one social setting to another is done by most people on a regular basis (Aikenhead, 1996). However, moving into the subculture of science presents a particular challenge (Aikenhead, 1996). Brand, Glasson and Greene (2006) identify this challenge as a "border crossing" (p.3), a barrier to underrepresented minority students as they negotiate certain beliefs and conventions prevalent in the STEM world that may exclude or discourage their participation. Borders can potentially be impartial or stressful as they

produce obstacles making movement difficult (Stanton-Salazar, 1997). The participants in this study reflected an insider/outsider tension that weighed on their minds stemming from being in a minority based science program. From the insiders' point of view, the environment in an HBCU STEM program was safe and accepting, where issues of race didn't matter. From the outsiders' point of view, the environment outside the HBCU STEM program was uncertain and tense. According to Brand et al (2006), underrepresented minority students feel unsure about their abilities to be successful when they move into science and math contexts due to the lack of role models for students to emulate. For these participants, they were moving from one context, where they felt comfortable, to another context with different expectations. The interview data demonstrates that the participants recognized the boundaries between the two worlds and looked for strategies to manage those boundaries.

Danielle deliberated about the difference between perspectives. She felt comfortable in the program but accepted the fact that the outside was different. By reconciling the differences between the two worlds, she rationalized the transition to her next location:

People asked me why I didn't consider an HBCU for graduate school. Before I came here, I learned to work with people from different backgrounds then I got a taste of working with people similar to myself. I don't want to get too comfortable with that, especially in science. There is a whole different world out there.

Precise made an insightful comment about race and being inside a HBCU. He felt he could be himself:

When you are at a HBCU, you have the luxury that people can take you at

face value unlike the predominately white community I grew up in.

You can say, "Oh, I'm a computer scientist and people will say "OK, that's cool".

He noted that the acceptance he felt "inside" was not the same in the outside world. He remembered being one of the few minority students in a summer research program and how he was described:

But, if you go somewhere else, there have been a few times where people say "oh, that's the black guy doing computers" and stuff like that. I know that is correct but why was the first part even a thing.

Danielle added to the descriptions of the insider/outsider perspective. She applied to a summer internship and received notice that she was accepted. After her acceptance, she was asked to send a picture of herself:

Between the time I was accepted and the time I sent my picture, they were filled to capacity. I know people who say "don't fill in the race box on an application", then you could be anything. But I always do because I want to be upfront-it's me! Don't give me a false hope.

Danielle felt that in some way she had been deceived because she did not fit into some ideal model of what a STEM student should look like, her acceptance was rescinded. The timing concerned her since it happened after she sent the photo. This experience was a disappointment to her and led her to believe that she did not fit into the expectations of that science setting. As an African American woman with dreadlocks, her image was discordant.

Like Danielle and Precise, Ashley also discussed her reflections of insider/outsider perception. She attended a lecture given by a recent graduate of the HBCU STEM program who came to speak about his graduate school choice and experiences in a PhD program at a nearby medical college, his opportunities and challenges. He described an environment that was unwelcoming:

He said it was hard, but especially because the other students didn't want to work with him, because I guess they felt like he wasn't good enough in a sense. They felt as if he didn't know as much as they did.

The young man was a recent graduate of the program and had worked with many of the students he spoke with on that occasion. He was well-respected and admired by the underclassmen:

Over here, he was top dog. He made a high GPA. I think it's like either a 4.0 or it's very, very close, like a few points shy of 4.0. He's always been smart.

Using the experience of this alumnus, Ashley questioned efforts being made to make the sciences more diverse in the outside world:

How serious is this commitment? There are not a lot of people that look like me in the science field. It's like they want you, but they don't want you.

From the personal perspective, Ashley felt that the young man's narrative gave her a segue into her own feelings:

I've always felt the need to prove myself in science, because I've been afraid of failing I felt like I wasn't good enough so I have to prove that I am just as good as someone else.



When discussing the topic of negotiating race in a STEM field, Brianna shared a personal experience with me. Although the event did not occur in an educational setting, the incident caused her to reflect on perceptions of race on the “outside”. Brianna prides herself in a strong sense of awareness that her parents instilled in her as a “black woman”. What that meant was not going certain places, not doing certain things, and not hanging out with certain people because she would be “judged first as being black”. During the summer she worked at a mall in the town where her parents live. One day, as she and her sister were eating lunch on some benches in the common area, there was a fight between two African American teenage boys. The police were called. They questioned the sisters implying that they knew these two individuals, and that they were accomplices of some sort. Neither girl knew these teenagers nor had they ever talked to them. The interrogation mortified Brianna and her sister. She describes it this way:

It was only because they saw that we were black and they were black. But what they didn't see was that I was a physics major, and I couldn't tell them my GPA, and I couldn't tell them all the other great things I had done, because they didn't see that, the only thing they saw was my skin color.

Brianna's experience revealed her personal feelings about the inside/outside perspective. Inside the STEM program she was recognized as an exemplary student and physics major; but during that incident, she was assessed solely on race.

Crossing the border between a STEM HBCU and other STEM contexts is an important mechanism that fosters shifts in emerging identities. Over the course of an underrepresented minority student's STEM trajectory, images and social factors such as a dearth of role models, isolating learning environments and negative messages about race

in their disciplines of choice present challenges that can make their transitions less than smooth. The students in this study who have chosen to enter these fields have proved themselves to be capable of academic rigor; however unwelcoming perceptions and negative messages can shake their resolve illustrating the impact of social influences on underrepresented minority students in STEM fields. Their reflections of race and access to STEM fields uncover the tensions they have experienced between their program and the outside world.

### **Lived Others: Social Ties and Networks as Building Blocks to Identity**

I turn the lens to the last existential of *lived others*; as Van Maren (1991) reminds me as a researcher “one existential always calls forth the other aspects” (p.105) keeping in mind how the four existentials are intertwined with each other. This existential was considered last because relationality permeates every other existential in a significant way. Although some data coded as *lived others* could have been applied to one of the other themes such as time or space, I intentionally set them aside for this section since this existential points to the importance of quality resources attained through relationships that strengthen STEM identity and STEM social capital. When the participants choose to discuss certain relations as meaningful to their STEM pathways, those relations continued to appear as important facets of their lived experiences in this category. From analyzing the data, the theme that emerged was social ties and networks as building blocks to a STEM identity.

Putnam’s (2000) definition of social capital as the “connections among individuals—social networks and the norms of reciprocity and trustworthiness that arise from them” (p. 19) parallels the experiences of the STEM participants in this study.

Social ties, networks and norms of study serve as important links to their community life in the program, reflecting what scholars have noted about the value of social capital for young people moving into a profession (Bourdieu, 1986; Coleman, 1987). Stanton-Salazar and Dornbusch (1995) describe criteria for determining if networks and ties augment the social capital of underrepresented minority students. The criteria they suggest is: a) a tie or network provides institutional support; 2) the resources direct students to valued information; and 3) support is specific to the needs of the individual. Lin (1999) adds to the notion that networks have value to individuals by citing that networks can ease the flow of information especially in facilitating opportunities and choices. Furthermore, Lin (1999) adds that individuals in a network find connections to other networks that can be advantageous to them in a strategic way. Ties and trust with educators provided students with valued information about graduate school and research, helpful professional networks and access to an academic STEM community. Since individuals occupy time and space interdependently with others, one's interpersonal relations have profound effects on framing their lifeworld.

As the program is housed within an HBCU, there is an additional element of social capital and network building other researchers have described (Brown & Davis, 2001; Freis-Britt & Turner, 2000); that is, that HBCUs foster a nurturing and supportive learning environment. Brown and Davis (2001) added the lens of social capital to their research on HBCUs to describe how networking and community building in these institutions facilitates the transmission of "social awards, such as status and privilege" (p.41) and entry into professions and organizations. The precepts of communities of practice (Lave & Wenger, 1991) complement the research on HBCUs and social capital

by emphasizing the importance of building relationships with other members of the community who share a common interest. In this study of underrepresented minority students in a STEM HBCU, the students are participating in a community of practice where they are becoming a “person-in-the-world, as a member of a sociocultural community” (Lave & Wenger, 1991, p.52). As referenced by the participants in this study, the individuals engaged in novel activities, performed new roles and developed discipline knowledge (Lave & Wenger, 1991) in STEM fields.

Similarly, a peer-to-peer mechanism within the program builds social bonds among the students through a required tutoring program. A distinct element of the program requires that students are tutored as freshman and sophomore by upperclassman, then they switch roles to become the tutors in their junior and senior years. The mandatory interaction keeps students from feeling isolated and maintains norms of study and practice within the discipline. The students all live in the same dorm, share common study hours, a common study place, and have assigned “study buddies” in the same major. Smardon (2011) dubbed the term “kinship science” (p.896) in her research to emphasize the potential for change that interpersonal relations can have in educational settings. She describes “kinship science” as a strategy that can be used in science classrooms that builds on strong social bonds among students themselves, whereby students work together to adopt the norms of science learners, recognizing that peer relations can influence aspirations and achievement by building peer-to-peer social capital (Stanton-Salazar, 1997). These social bonds allow for competition and discourse toward a shared goal of academic excellence.

Since the purpose of this research is to examine the role of social interactions in enhancing or constraining student pathways in STEM disciplines, I consciously focused on relationships between students and educators and peer-to-peer relationships within educational structures in this section. The reasoning is as follows. Each of these participants represents a different environment in terms of the high school they attended, the locations and resources of those schools, and their familial backgrounds. Those factors are outside the control of educators and do not provide any guidance to educators as to how to optimize educational settings (Tate, 2001). Thus, as a researcher I am not denying the impact of families as much as focusing the lens on educational strategies and how those pathways can be maintained and sustained in a methodical and purposeful manner within the walls of schools and universities. Taken all together, these terms and definitions provide a view of how social structures and relations can impact an individual's STEM trajectory. For this reason, in this existential the two categories that evolved were: relationships with significant non-familial adults that support STEM identities and peer-to-peer experiences that support STEM identities.

**The influence of significant non-familial adults.** Danielle described social ties that both opened her professional network and were specific to her needs as a student. Regarding the issue of trust and norms in relations, Danielle noted the following as particularly meaningful to her STEM trajectory. During her sophomore and junior year, she worked regularly conducting research in a lab on campus with one of her professors. In this setting she was able to develop competence in a science setting and achieve recognition for participating in science practices. Over the course of her work with this

professor, she altered her plans for graduate school based on his professional advice to her. His personal influence was as follows:

He was one of the first people who noticed I had been going back and forth between the idea of going to medical school and grad school. He forced me to think about what I wanted to do. That was a turning point.

Not only did she feel valued for her contribution but his personal interest in her future plans were indicative of her potential in the field as recognized by a practicing scientist. She pursued a program suggested by her professor where she eventually was accepted for a Master's degree in Food Science. He made recommendations, suggested she talk to certain people in the program and encouraged her to look into this course of study. The university was also her professor's alma mater.

Danielle attributes her recognition by her professor as well as her lab work to building confidence in herself as a science person. While visiting the graduate program, she pursued a lead on a professor who was doing research on the physiology of listeria on produce when eaten by pregnant women. She refers back to her research as an undergraduate:

I had already done some research in microorganisms. When I went to check out the school, my advisor brought that up and asked me if I wanted to join her research. I believe that my experience here gave me the competitive edge.

Ashley recalled an experience similar to Danielle's in terms of increasing her opportunities and exemplifying norms of science. Last semester, she presented her findings from her research project the previous summer in one of her classes. After

completing the assignment, her professor asked her to join him in some overlapping research he was in the process of conducting:

He didn't understand why I had not talked to him sooner. But he asked me to do the research with him because he saw that I already had experience synthesizing different drugs and different reactions. He was impressed and saw that I could bring something of value.

Ashley was honored to be personally invited and the experience made her feel relevant as a science person. This recognition opened the door for her continue with work she had started previously, as well as giving her current practice she could use for graduate school applications.

Precise praised the fact that in a small program, a student could make those kinds of personal connections, where someone like Dr. Hudson could "see" how his skills could transfer to another area and what skills might limit him in the field. She provided him with guidance and recommendations about experiences and opportunities he needed to pursue to showcase his skills. The opportunity to work with someone in his field, to "put time in for him" was significant and made him feel like he was a "part of it". Precise reflected on how this professor made him feel part of the community of practice:

You feel a good sense of community here-you feel like you are part of something bigger. We have a robotics competition every year that Dr. H runs. She lets you you know that she is looking out for your work, for you personally, expanding your knowledge and skills in the field, rather than just what is required in a course.

Ashley, Danielle and Precise's experiences highlight the professional and career benefits of interactions of students with professors in research settings. Jason had a similar experience. His advisor put him in touch with someone doing research that had an unfinished project in electro active polymers and was looking for someone who would be interested in taking it on. He had been part of it for the past few months and he described it as follows:

The professor had given me a lot of freedom-working at my own pace, no tests, no deadlines I've been watching videos learning how to use the software, the actual physics behind it.

Jason felt a sense of accomplishment that the professor he worked with gave him so much independence. She met with him every two weeks to discuss his progress and answer questions:

My life is centered around physics-everything I do, including this research.

My first actual presentation of this research is coming up next week.

Jason's advisor steered him in the direction of this research opportunities based on the competence and skills that he demonstrated from the work he had done the previous summer. Now he needed to continue "touching up his resume" which this project allowed him to do.

Jose described an interaction with one of his professors where he was recognized for demonstrating ways of acting and thinking in science. Jose had applied for a summer research program in California and asked his chemistry professor for a recommendation. In the recommendation she wrote, she described how he worked in the lab with his teammates and the characteristics of someone practicing science. He explains:



How she described me in the recommendation really touched me-she noticed how I took the lead in my team, how I divided up the lab work, how I wrote the lab report. Reading that made me feel a part of chemistry.

For Precise, Jose, Jason, Ashley and Danielle being a member of their community of practice required working with others, taking on new tasks and modeling norms of their discipline. In the process of developing their identities, they developed skills that they were able to demonstrate as part of their practice. Whether teaching, leading or doing, they were moving to a fuller understanding of their roles in their fields of study.

Marlone and Barabino (2008) cite recognition from others as an important element in identity formation in STEM fields. The recognition for their abilities and acumen had a positive impact on their pathways and provided personalized advocacy. These experiences validated the participants giving support to the merit of social interactions in educational pathways. Through experiences such as these, the participants were “situated” (Lave & Wenger, 1991) in a specific context where they were able to master competences and norms of the discipline furthering their process of an emerging identity.

**Kinship science.** Referring back to the term coined by Smardon (2011), “kinship science” (p.896) recognizes the strengths of student-to-student relations in creating a peer culture and peer-to-peer social capital (Stanton-Salazar, 1997). With the exception of Jose and Supreme, the other participants attached noteworthy importance to their roles as tutors. When I asked them to describe a typical day, each of them talked about setting aside part of that day for their responsibilities to other students. When Brianna described her typical day, she gave the following scenario:

We all live in the same dorm so getting help on problems is easy. You'll ask your peers and they'll assist you. People come to me and say they need help in setting up circuits or volt shortage. We help each other at night.

The commitment to these intra-group supportive ties gives each participant a role in contributing to the success of others in the program. Brianna explains her tutoring commitment:

We have to do two hours a week with tutoring-that is our responsibly. We often do more and it's simple, easy and effective and you can't stop after two hours if someone needs you. The year after you took the course, you think I know this really well-it helps you register it in your mind as well.

As the older students tutor the younger students, not only does it reinforce their own knowledge of the material, but the process is beneficial for transferring and modeling norms of science from one group to another. Jason describes his commitment to tutoring:

I tutored math and physics and some calculus. I would end up helping people at night and staying up till two o'clock to finish my work but it seemed helpful. People asked questions and I actually lost my voice once I was instructing so much.

Brianna and Jason were not only acting as teachers but also as role models of what an effective underrepresented minority students in a STEM field looks like. For Precise, scheduling his tutoring session is a vital part of his daily routine:

I personally do the tutoring for the computer science students in the program so that dictates how my day is going, I usually get in touch with others to set that up as early as possible, making sure I am available when they need me.

Supreme is in the younger group so he “gets tutored from two others” and as he moves along he knows that he will tutor others. He cites the tutoring program as being more than informational for him. Hearing from those who have gone before him and who have done the same major. He describes those interactions:

I like talking to them. It really helps when you are feeling stressed out around exam time. They tell you to keep trying, stay calm because they have been through the same thing you have.

Supreme was able to illicit coping strategies from other students that he respected and saw as successful in the program. When I asked Danielle about the benefits of tutoring, she described the following:

What one doesn't understand, the other will. You don't want to see your friends leave because they weren't keeping up so if someone doesn't understand or is struggling, I try to help. I know that can be embarrassing but the way it is set up, everyone has someone to help them.

The requirement of “old timers” tutoring “newcomers” speaks to the principle of performing new roles and engaging in new activities. The tutoring work goes beyond the academic knowledge and moves into “community maintenance” (Wenger, 1998, p.74) where students take an interest and responsibility for other students reflecting the importance of the success of the program. Danielle talks about her ties with other students:

When you get here, you have to build a sense of community. You can do that by getting with your peers in your classes and realize you will need each other.

You also stay connected with your mentors and tutors; they are going to make sure you stay.

Danielle described how this idea of working together is ingrained in her and the principles of the program:

I learned a sense of community the hard way. During my freshman year, some of us chose to work alone and didn't get a network going and some of those students didn't come back. I was saddened when I found out I was the only one in my suite coming back to build my community alone.

The revolving responsibility of tutoring is similar to what Lave and Wenger (1991) describes as "legitimate peripheral participation" (p. 29) with "older timers" working with the "newcomers". By establishing that cycle, the students who were tutoring described how they felt they were strengthening the program for the future. The tutoring process also created a peer-to-peer support network that was caring and readily accessible. The students recalled feeling protective to the younger students trying to make sure they stay on track. At the same time they are instrumental in supporting an opening to the newcomers as they gain access to the norms and practices of their academic disciplines edifying the value of learning and teaching others.

The existential of *lived others* is broad and multi-dimensional as far as the impact on the participant's STEM trajectories. Every participant described some experience with either an educator or a peer that touched them in some way to move them along on their pathway. In seeking to find ways to expand educational options, these students have cultivated and maintained various social relationships that have informed and motivated

their choices. In negotiating their growth in an area where they are underrepresented, these social settings and interactions empowered their identity formation.

### **Summary of Chapter**

In this chapter I presented the findings of a phenomenological study of the lived experiences of underrepresented minority students in a STEM Honors college at a public HBCU. Using Van Marén's (1991) lens of four existentials to analyze the lifeworld of the participants, four themes emerged: aptitude to aspiration, opening a portal, tension between race and STEM identity, and social ties as building blocks to a STEM identity. By considering the existential *lived time*, the participants reflected on how their trajectories to a STEM discipline were forged over time by the recognition of their aptitude in challenging courses, exposure to authentic learning experiences, and the realization that a course of study could translate into a career that could have a positive impact in medicine or science. By considering *lived space* after time, the participants cited examples of how various kinds of spaces influenced their pathways, specifically the program itself and the off campus research sites. As all the students were African American, looking at *lived body* provided an opportunity to contemplate the messages of race in STEM careers and the tensions they have observed in their own trajectories. And in considering *lived others*, the participants pondered the influence of relations with educators, their peers, and family in creating a network and support system to propel their success.

In looking over the data and the themes that emerged, there are several patterns that merit discussion. With regards to *lived time*, all the participants with the exception of Precise had pivotal experiences with rigorous STEM content in high school. For Supreme

and Jose, they reported being identified early as having potential in math and encouraged to take advanced classes. For Brianna, Jason, Ashley and Danielle, particular science classes were influential in encouraging them along a STEM pathway such as physics and chemistry. Although Precise took a computer Science class in high school, he did not find it to be especially challenging or inspiring. Regarding the altruism effect, Precise and Supreme did not report any feelings about using a STEM major to make some societal contributions. On the other hand, Brianna, Ashley, Danielle, Jason and Jose all reported that they felt they could use a STEM major as a vehicle for contributing to society either medically or socially.

With regards to *lived space*, all the participants with the exception of Supreme and Precise lauded the unique characteristics of the program. Supreme expressed concern that the curriculum was too confining but for Danielle and Jose, their only concern was to reconcile committing to a STEM major as opposed to another field, but ultimately they seemed content. Ashley, Brianna and Jason recognized that the program was defining for them in terms of opening doors to their respective fields and seemed to readily embrace the opportunity. In thinking about their summer research programs, all the participants except for Jose and Supreme regarded those opportunities as eye opening and momentous in helping to construct their STEM norms and practices through the research settings and the opportunity to be published. Since Jose and Supreme were the youngest of the participants, they had not had the occasion to attend one of these summer research programs and were planning on doing so during the summer after the interviews took place.

With regards to *lived body*, all the participants with the exception of Supreme, shared tensions that they personally experienced with regards to race and the STEM world. Jason and Ashley discussed their own feelings of insecurity about themselves and their ability to compete while Jorge observed the lack of role models as portrayed by the media. Danielle and Jason also discussed the idea of role models but turned to their experiences in the program at a HBCU where viable role models do exist. Brianna and Precise considered their role as minority students in a research setting and dual meaning of race in STEM contexts.

With regards to *lived others*, every participant acknowledged and appreciated the impact of relationships with professors and the community of scholars on their STEM trajectories. For some, like Jose, Danielle, Jason and Ashley, that important relationship was with an educator whose recognition provided them access to an important opportunity and resource. For Brianna, Jason, Precise and Supreme, they participated in a network of their peers where they were both the “old timers” and the “newcomers” in ways that were important for their own trajectories as well as those of others. They all spoke of the importance of sense of a community that was generated by being part of this program, both from the perspective of the program itself as well as the larger community of practicing professionals. These interactions enhanced both their professional social capital as well as their peer-to-peer social capital where all participants were responsible for being part of the success of the program by supporting each other.

### **Looking Ahead to Chapter Five**

In the final chapter, I will provide a general overview of the study and then revisit the research questions. Following the introduction and questions, I will divide the chapter

into three sections. In the first section, I will discuss my findings by answering each research question based on interview data. In the second section, I will consider the implications of the study in terms of African Americans students' STEM identity development. And in the final section, I will consider the lessons learned from the study (e.g., phenomenology as a research method) as well as the limitations of the study.



## CHAPTER FIVE

### DISCUSSION

On the thoroughfare to identity formation, individuals are situated in contexts where they make and remake their identities as they participate in surrounding social systems (Roth & Barton, 2004; Hoover, 2004) that emphasize the interconnectedness between the individual and the world around them. Since students of color are still underrepresented in STEM fields, this study considered a specific context where underrepresented minority students were matriculating in STEM disciplines and how their respective identities took shape. In chapter two, two metaphors were employed: a river to portray the flow of potential talent and a pipeline that represents stages in the educational process that can facilitate or limit aspirations that can impact commitment. The particular focus of this study lies with students' experiences of developing a STEM identity from high school to a STEM college at a public HBCU and the experiences and contexts that enabled their goals. As described by Bowen and Bok (1998), for underrepresented minority students a journey on the river to reach their goals is unpredictable with unforeseen bends along the way. For Johnson (2007), the educational pipeline is problematic in preparing underrepresented minority students along the way to attainment with crucial leaks and vital blockages alongside. In traversing rivers and pipelines, many people and opportunities made the participants' pathways and bridges to success possible.

A phenomenological methodology was deemed appropriate for this study because I was seeking to generate an understanding of the pipeline from high school to a STEM program at a public HBCU from the lived experiences of the participants' in the study.

The overarching research question was: How did African American students at a STEM Honors College at a public HBCU develop and incorporate a STEM identity from high school to their undergraduate years? The specific research questions were as follows:

1. What is essential about being a STEM major?
2. What experiences and contexts did they attribute to constructing a STEM identity?
3. How did they experience and negotiate their other social identities with a STEM identity?

The remainder of chapter is organized into three sections. In the first section, I will discuss my findings by answering each research question based on interview data. In the second section, I will consider the implications of the study in terms of African Americans students' STEM identity development. And in the final section, I will consider the lessons learned from the study (e.g., phenomenology as a research method) as well as the limitations of the study.

### **Looking Forward**

In order to answer the research questions, I went back to the literature review and connected the findings of this project to the existing research on how social capital and identity formation interact and applied the analysis to the data in this study. In trying to generate an understanding of the process of STEM identity for these participants, I first considered what involves the "essence" or what is "essential" about being a STEM major following the precepts of phenomenology. Secondly, I consider the various contexts and experiences that opened the participants' pathways to a STEM community of practice.

And finally, I explore how the participants negotiated their other identities in the process of becoming STEM students.

### **The Essence of Being a STEM Major**

The first research question focuses on what is essential about being a STEM major from the participants' perspectives. Considerable research uses the term 'pipeline' when referring to how underrepresented minority students' interests and persistence in STEM fields can be strengthened or augmented (Engberg & Wolman, 2013). Some researchers discuss specialized public high schools (Subtonic, et al, 2010), intervention strategies in elementary schools (Varelas, et al) and higher education programs either in HBCUs or PWI (Predominately White Institution). My research has led me to consider the potential of a STEM pipeline for students from high school to a HBCU STEM program and the influence of relational networks (Stanton-Salazar, 1997) that enabled the students to bridge an identity from one institution to another and follow their personal trajectories. Drawing on social capital and identity theory, I will frame the essence of being a STEM major at a HBCU Honors college around three ideas: competence, community and commitment. The essentials of the students' lived experiences in this study will be presented one by one using these concepts.

**Competence as a key for membership.** Carlone and Johnson's (2007) study on underrepresented minority women in science proposed that in order to be recognized as competent in one's field, the individual had to demonstrate relevant practices that were recognized by others. They suggested that achieving competence is an important step in identity formation since one's accomplishments had to be recognized by others who held some stature or authority in the professional field. In Stanton-Salazar's (1997) framework

of social capital experiences for underrepresented minority students, he emphasized the power of non-familial adults in educational settings as having the capacity to “initiate and foster the development of proper dispositions and motivational dynamics” (p.3). For the participants in the MASI program, non-familial adults played a key role in recognizing, encouraging and fostering their pre-college academic math and science dispositions. In doing so, the participants pursued higher level courses and interests. By maintaining their interest and skills, their pre-college competence in math and science was recognized when they were accepted into the program. Given the selectivity and financial support that the scholarship offers, there is an implicit expectation of their prior knowledge and abilities. For these participants, getting into the MASI program recognized their competence in math and science and afforded them entry for “being the right kind of person” (Wenger, 1998, p.101). Their experiences allowed them to acquire resources that helped their future identity construction and continued their momentum toward a STEM trajectory. By succeeding in rigorous courses prior to starting the freshman curriculum, they had already proven themselves competent enough to be granted initial entry into a community of practice putting them on an “inbound trajectory” (Wenger, 1998, p.154).

Aschbacher, Li and Roth (2009) studied underrepresented minority students in the STEM pipeline during high school to understand what factors contributed to some students persisting while others left. These researchers found that students became frustrated when their grades slipped in hard classes and their identity shifted away from a math or science identity as a result. Conversely, STEM identity was “deepened by competence and positive assessments by self and others” (Ashbacher et al, 2009, p.579). For the students’ in this study, they began a trajectory in relation to a specific community

of practice when they entered the program, and remained there for four years based on their initial competence. By matriculating in the program, not only do the students prove their competence in their discipline community, they also fostered other trajectories where they move into a future context and find a new place in the community of practice. For Precise and Danielle who are graduating seniors, their “outbound trajectories” (Wenger, 1998, p. 155) were evidence of how meaningful their identification with particular communities of practice can be for the future. Both students were accepted to STEM Masters’ programs and are continuing their studies, hence a further verification of competence. Learning in the MASI program characterized their trajectories as moving closer to identifying with a STEM discipline.

Competence continues to be essential throughout their four years in the STEM program. Once they are inside the program, the students as STEM learners participate by immersing themselves in their studies, keeping up their grades, and participating in research within the program as well as outside the program. The participants also described “overlapping forms of competence” (Wenger, 1998, p. 76) acknowledging the different specializations available in the program as well as different strengths members demonstrate, such as those who are especially skillful in teaching others difficult concepts to other students. Their identities as STEM majors are still “interlocked and articulated with one another through mutual engagement” (Wenger, 1998, p.76), maintaining the standard of achievement that is expected of their membership inside the organization. By being in the program, they prove that they can competently interact with new knowledge, new experiences and the demands of membership and frame what is important to them in terms of their community of practice.

**The HBCU as a community of practice.** For the participants in this project, a sense of community and a community of practice were essential to the development of the STEM identity. In Palmer and Gasman's (2008) research on HBCUs, they concluded that these institutions of higher learning have an "abundance of social capital" (p.54) as a consequence of their historical background. Allen (1992) maintains that HBCUs espouse certain goals that are specific to that context. Some of those goals that are relevant to this study are: a) role models in higher education that can act as researchers for the social, political and economic dynamics of the African-American community; b) college graduates with unique skills that can address issues in the African American community; c) the production of African Americans in specialized professional areas that deal with the environments of African American and other minorities. In actualizing these goals, HBCUs act as brokers of social capital by distributing and reproducing networks and resources for their students, according to Brown and Davis (2001) who modified Bourdieu's (1986) theory of social reproduction. Instead of social capital being accumulated and reproduced for an elite economic class as Bourdieu (1986) contends, HBCUs "serve as conduits for the production and transmission of social capital to African American students" (Brown and Davis, 2001, p.41). The participants in this study mirrored the goals that Allen outlined and the social capital they gained from being part of the program. Several of the participants referenced the value of role models in the STEM community that came into contact with in the program. For the younger students, the professors and older students served as role models as Allen (1992) discussed, while demonstrating how "to act as members and engage in the learning that membership entails" (Wenger, 1998, p.277). Jason reflected about the inspiration that he felt from

being in the program, he looked around and saw that he was a “member of an elite group of African American scholars”.

In their research on informal mentors and Latino youth, Stanton-Salazar and Spina (2003) stress the importance of “special adults” (p. 233) in a community who acted as informal mentors that provided individuals with targeted educational counsel, emotional support and embodied characteristics that were worthy of emulating. Stanton-Salazar (1997) suggests that underrepresented minority students can build their own social capital through peer-to-peer networks. Similarly, Smardon’s (2011) suggests that the concept of “kinship science” (p.896) would yield beneficial results about the significance of relations among peers and the role that relationality can play in developing early science identities. The participants in this study reported positive and fruitful associations with older students in the program who acted as informal mentors and tutors. The tutoring requirement of the program served as another element of building social capital in peer-to-peer networks creating conditions to support academic success. Johnson (1981) lauded the benefits of peer-to-peer networks, claiming that peer relationships influence aspirations, achievement, and attitude towards learning. All the participants discussed their role in the tutoring program as either being tutored or now tutoring others. The “newcomers” “old-timers” (Lave & Wenger, 1991, p. 95) dichotomy puts the younger students in the role of observers as they receive the benefits of being tutored and mentored while learning the expectations. The tutoring requirement served as a general community building process as well as an invitation into a community of practice.

In their day-to-day activities, the participants' interacted with a specific curriculum and a learning environment that was situated in an explicit context. Over time, the participants' worked themselves into an established trajectory, e.g. matriculating STEM majors. Being in a STEM program inside a HBCU, the students benefited from the community and social capital building of HBCUs in general, as well as gaining membership into a more exact community of practice of a STEM major within this specialized program. Steiner (2005) establishes the connection between social capital and communities of practice. In her research, the author designates communities of practice "knowledge management" (p. 78) where individuals inside the community develop social capital by acquiring new knowledge and experiences and sharing those elements within the community. As research inside and outside the program is an example of a "mode of belonging" (Wenger, 1998, p.173) to this program, the students benefited from the networks and social ties to build their repertoire of practices in their fields. Research opportunities were critical for the participants to connect what they were studying with real world applications of STEM knowledge. The networks that led them to these experiences allowed them to present their research to their peers and professors, contribute to larger research endeavors and to be published. Wenger (1998) emphasizes the process of reification as being fundamental to engaging in a community of practice as to reify produces something in a "congealed form" (p.59). As relations in a community are formed around practice (Steiner, 2005), for the participants in this program, this interaction with experts expanded networks and resources that are available to them.

**Commitment as an essential.** The third essence to be considered of being a STEM major in this program is the essence of commitment. By signing the formal



contract of agreement to accept the scholarship, the participants were aligning themselves to the principles and conditions of participation. This alignment entails following commitments: a) they commit to one of the seven STEM majors in the program, b) to live on campus in the program dorm for all four years; c) to maintain a 3.0 GPA; d) to participate in tutoring, mentoring and community service; and e) to participate in at least two summer research internships. Most of the participants had already decided that they wanted to pursue a STEM major; Danielle and Jose were the only two who initially said they considered a different major. For all the participants, however, by agreeing to this contract they were complying with the requirements official requirements of the MASI program. By doing so, they reconciled the demands of the program with their potential for the future.

McCune (2009) employed the communities of practice framework in a study of final year bio-science students. By considering the bio-science major discipline as an example of situated learning (Lave and Wenger, 1991), McCune (2009) concluded that students' levels of engagement and commitment to learning are increased when the individual perceives themselves as "part of a particular world" (p.359) and sees their learning experiences as relevant for developing their future identities. Likewise, the participants in my study reported a willingness to make a commitment to the demands for a long term goal of a STEM degree. Jason, Brianna and Ashley talked about making sacrifices echoing what Wenger (1998) calls "an investment of personal energy" (p.181). Others talked about the personal toll of staying up late and studying and putting their interpersonal lives on hold in terms of having a relationship with someone of the opposite sex, showing how commitment is necessary to become part of something bigger.

In addition, by entering the program, the participants made realistic commitments to roles and values that fit with their long term goals as learners. In order to sustain those commitments over time, personal commitments required support that came from within the context (Hoover, 2004) of the program. The participants discussed two motivational strategies that were regular features employed by the program that served to sustain their commitment to the STEM program: guest speakers and program graduates. Wenger (1998) identifies a mode of belonging to a community of practice as “imagination” (p.173), where members image their futures in the world outside the program and see their potential as a reward for sustaining their commitments. During these weekly sessions, the students envisioned themselves as those individuals who have completed a STEM discipline and see all the possibilities of their future before them. For the participants, these two strategies served that purpose.

For instance, once a week, throughout the four years, students were required to dress professionally and attend a lecture from outside resources regarding their professional futures. The speakers were either representatives of STEM graduate and medical schools, representatives from the government or private industry that employ STEM graduates or representatives of universities looking for summer research participants. This specialized access to information increased their social capital as well as allowing the students to be engaged in the ongoing process of constructing their outward trajectories as members of a community of practice. By dressing professionally, they could “see” themselves in a role but also had to present themselves in a role. Through these visits, the students were able to gain an understanding of how the requirements of the program, such as the curriculum or the GPA, reflected the

requirements for graduate school and pathways outside the program. By listening to presentations on research internships, students developed networks outside of the program that could enhance their future social capital by meeting professionals who had similar research interest or ongoing projects. By connecting with opportunities in the work force, students could begin to envision a pathway for their future and recognize how learning and practice construct their identity.

Some of the speakers were also graduates of the program, an aspect of the guest speaker sessions that was particularly important to the students in this study. Brianna described how she found out that one of her physics professor was a graduate of the program, who went to another institution for her doctorate's and returned to teach there. Ashley talked about how one of the graduates was attending the new osteopathic medical school in the state and how she felt that gave the program validity. These weekly sessions served as regular reminders of the importance of sustaining their personal commitment as well as their roles in the broader meaning of the program as a community and the community of practice of a STEM discipline.

### **Constructing a STEM Identity**

The second research question focuses on the experiences and contexts that students attributed to constructing a STEM identity. The participants described experiences and context from pre-college up to their time in the STEM program. Since the principles of *lived space* as discussed in Chapter four have particular relevance for this question, some of those experiences and contexts will be revisited in this section.

**Pivotal pre-college experiences.** When students reflected on their pre-college experiences and contexts, all the participants reported engagement in STEM content

either through classes or authentic learning experiences in the classroom or outside of school in STEM spaces in high school. Some of the options available to students were advanced classes in math and science, summer STEM academies or medical specialty academies throughout the school year. These experiences and contexts were in some way pivotal in piquing their STEM interests as well as moving them from interest in a subject to building competence and expertise (Subotnik et al, 2010). By becoming successful academically, the participants engaged in settings where content learning and identity construction (Varelas et al., 2012) were “intricately fused” (p.328) as students grew to more confident in the academic knowledge of the discipline as well as the practices. In Coleman’s (1988) framework of social capital, resources become available to individuals by understanding the norms of a system. For these participants, they developed norms of study and discourse both for academics and for STEM habits of mind. Recalling Brianna and Jason, the high school physics class opened their eyes to “math applied in the real world”. Similarly Jose described being in an AP Calculus class and through the encouragement and recognition of his teacher, “knowing what he had to do” to be successful. Danielle also remembered being in Honors Chemistry as understanding how she could use science as a way to be creative. This interweaving of knowledge with a STEM identity in classroom contexts, allowed the student to imagine and represent themselves in STEM fields (Varelas et al., 2012).

Several students also reflected on learning experiences outside the classroom during their pre-college years where they visited hospitals, worked in computer labs with graduate students, or observed open heart surgery. These authentic learning experiences stimulated their dispositions serving as a springboard to their continued aspirations.

Kozoll and Osborne (2004) cite the problem for science educators is to convince their students that the study of concepts and theories can turn into a lifelong source of educational and professional inspiration. Furthermore, Maltese and Tai (2004) stress that the greatest attrition of STEM interest and STEM matriculation takes place in the time between high school and beginning college. Furthermore, these researchers (Maltese & Tai, 2004) stated that academic performance and the number of science classes taken in high school had a positive impact of STEM degree matriculation among underrepresented minority students. Thus, in considering the pipeline from high school to the STEM program in this study, the experiences and contexts of higher level math and science classes and the access to authentic learning activities enhanced the students' knowledge of norms of STEM learning and opened a pathway to their identity formation in a potential community of practice.

**The STEM program as a bridge.** On the bridge from one educational context to another, these students entered the STEM program in this study with nascent levels of competence in math and science and content connections (Wirtz, 2000) where they could extrapolate an educational direction for themselves based on committing to a STEM course of study. This is where the STEM program at a HBCU Honors college becomes the nexus between the two contexts by linking their emerging identities to a specific educational community of practice. Given the historical circumstances of the creation of HBCUs discussed in chapters two and four, the context of the program is significant. Recognizing that learning is a sociocultural process, where the program is situated takes on special meaning. Social capital is extended to these students through the connections and networks embedded in the program, and the interactions and mutual engagement

toward a common goal. The level of social capital is enhanced even more considering the generous financial support of the program, as an example of access to a resource based on membership to a group.

A number of researchers (St. John & Noell, 1989; Perna et al, 2009; McCallister et al., 2011) have reported that financial considerations are a critical element of persistence for underrepresented minority students in STEM fields and a potential obstacle to matriculation. All of the participants in this program made reference to the consideration of financial support especially when considering that most of the students had aspirations for graduate school. For some students, the scholarship as a resource compensated for the lack of familial resources. By enabling competent students to fulfill their academic dreams and potential, the program reproduces social capital in a way that these students would not have access otherwise.

**The salience of undergraduate research as a legitimate peripheral practice.**

When considering experiences and context, undergraduate research opportunities were key in both increasing the students' access to social capital networks and enhancing their trajectories to a STEM community of practice. The participants in this study indicated that the professors and administrators in the program were readily accessible and felt that had strong personal relations with them. Several students described "feeling like a family" and that their "peers were part of the family, with the professors in there, too". Not only did the professors act as role models and mentors but they provided them with targeted information about research opportunities and graduate programs. Undergraduate research opportunities within the program was indicative of the organization's acting as a "purveyor of social capital" (Palmer & Gasman, 2008, p.58) extended to the members of

the group. Participating in STEM research is also a mode of belonging to a group (Wenger, 1998) enriching their trajectories and membership. The students also described the importance of outside research experiences as opportunities to “reify” themselves as academics by giving them the prospect of presenting and publishing research in the broader STEM context outside the walls of the program.

McCune purports that students who had experiences in areas related to their programs of study were more likely to have a firm understanding of their possible trajectories as well as having the effect of engaging students in their context as it becomes more meaningful with authentic learning experiences. Brandt (2008) uses the term “locations of possibilities” (p.703) as places where STEM students can begin to develop a “discourse identity” (Gee, 2000). For Gee (2000) discourse identities require interactions across and among different groups where one’s work is recognized on the “micro-level” (p.122) on a day-to-day basis, reinforcing the importance of networks and experiences for emerging identities.

### **Negotiating STEM Identities with other Identities**

The third research question focuses on how the participants experienced and negotiated their STEM identities with their other social identities. Identity construction is an ongoing process (Abes et al, 2007) with individuals making and remaking themselves through the accumulations of experiences and social processes (Hoover, 2004). As the participants in this study are moving into a field where there is a shortage of underrepresented minority students, how they negotiate their identities in those fields takes on significance for them (Carlone & Johnson).

**Race and STEM identity.** In considering negotiating identities for underrepresented minority students STEM students, the essential of *lived body* is relevant. As the STEM community has long been a community of white males (Berrymen, 1983), underrepresented minority students moving into this community are cognizant of the long held “nuances” (Wenger, 1998, p.104) that represent social obstacles to participation. As discussed in chapter four, the participants in this study discussed their personal encounters that were subtle but challenging meanings of membership that they had to confront. Since the goal of this study is to generate an understanding of the lived experiences of these STEM students in their pathways, learning how these student develop strategies and mechanisms of support is crucial.

Jones and McEwen’s (2000) model of identity recognizes context experiences and core personal characteristics, as a multi-dimensional, interactional portrait of an individual. Recognizing that individuals are members of different social groups (e.g. race, socioeconomic status, gender) at one time acknowledges the complexity of one’s personal history in their learning trajectory. The participants in this study reflected on experiences that spanned from high school to the STEM program in this study. Starting with high school, most of the participants described experiences of being “the only one” (Marlone & Barabino) in advanced math and science classes. Although they expressed discomfort with the reality of under-representation, they also found ways to balance their identities as STEM students against other identities that were more comfortable. For Ashley, even though she was one of a few African Americans in higher level class, she reconciled that reality by reminding herself that most of those classmates were also in the medical magnet program with her. Being in that program was a source of pride and



success for her. Precise found another way to balance out being one of a few African Americans in the National Honors Society with his identity in high school. He defined himself as part of the “computer geeks” and the “anime club” where race was not as important as being up-to-date on the latest gadgets and terminology of computers.

Brianna described a strategy she used which was accepting that she was one of a few during class, but socializing with her African American friends during lunch. Tran, Herrera and Gasiewski (2007) describe this process “wearing different hats within multiple contexts” (p.28).

**Simplifying matters.** Another strategy that Tran et al (2007) describe for underrepresented minority students in STEM fields to negotiate their identity conflicts in and out of STEM fields is “simplifying science” (p.29) when they interacted with their families and peers who had no STEM connections. Along the same line of thinking, Aschbacher et al (2010) reported data from their study that students with parents who had little familiarity with STEM careers, tended not to recommend them. Several of the participants in this study discussed how they “simplified science” for their families by downplaying their accomplishment. Jason, for example, described himself as a “poor country boy” and did not want to appear like he was bragging when he’d go home to visit. As the middle child of seven children, he was the only one at that point who was pursuing a university degree. Danielle described herself as “growing up across from a pig farm” and that she came from a family of “domestics”. Her family was obviously very proud of her accomplishments, but she felt she had to downplay what she was doing.

Some researchers believe (Hurtado et al., 2009) that underrepresented minority students are likely to feel less tension in their social identities if they enjoyed early

success in math and science and encouragement from non-familial adults. For Jose, his source of inspiration was his teachers and their recognition of his potential in advanced classes. For Supreme, he remarked about being selected by a counselor to attend the summer STEM program as an example of being a “science kind of person”. Social capital, as a form of supportive ties with non-familial networks, strengthened their identity as doers of a discipline. Stanton-Salazar (1997) emphasizes that underrepresented minority students who can negotiate environmental factors that threaten their trajectories are more successful in reaching their goals.

**An emerging identity.** The participants discussed the need to continue to negotiate their identities when they were attending the STEM program in this study. For underrepresented minority students entering a STEM field, a challenge they face is how to become a part of and eventually a viable member of a particular community. Wenger (1998) discusses the idea of marginality and non-participation in communities where long standing practices are so ingrained that it becomes difficult to invalidate those practices and define one’s own trajectory contrary to long held beliefs. The participants in this program had to consider the marginality of science across institutions such as the border crossing discussed in chapter four. Hurtado et al (2009) uses the terms “micro” and “macro” (p 202) level to distinguish between learning environments that underrepresented minority students must negotiate. The STEM culture in this program encompassed two dimensions: on the micro level, the environment of the campus and program itself; on the macro level, the field as a whole. On the micro level, the students reported examples of enriching their social capital with resources from the community,

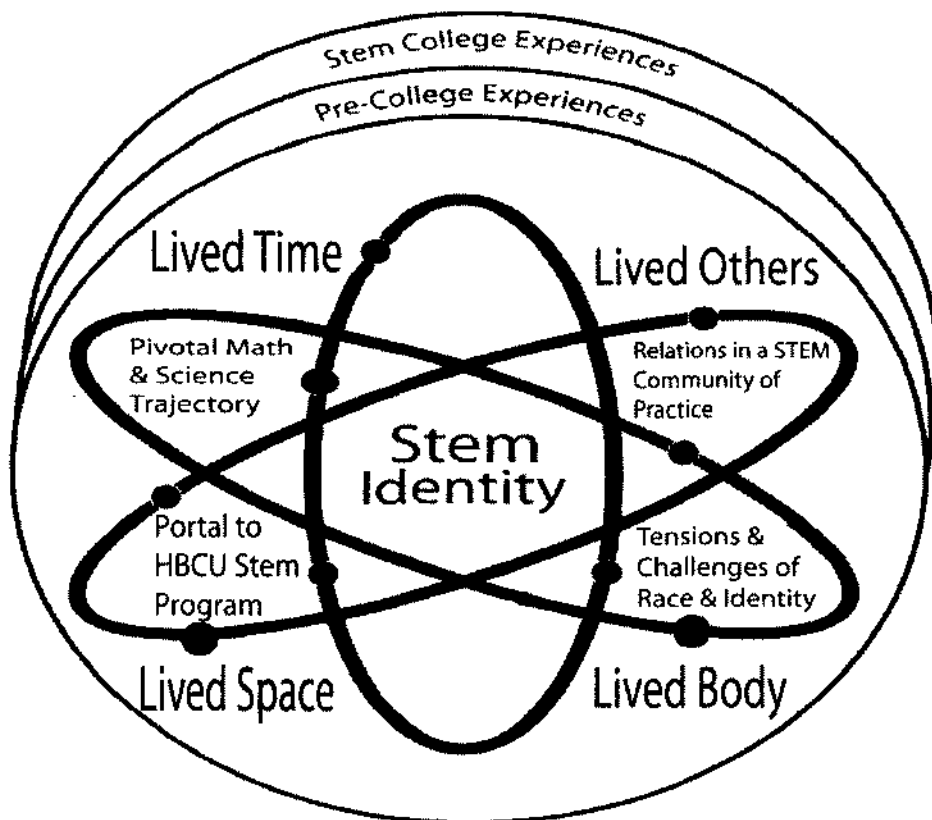
networks of information and mentoring in their fields. On the macro level, students reported crossing borders where the value of their HBCU education was questioned.

Wenger (1998) describes the concept of “multimembership” as the “nexus of perspectives” (p.105). As all individuals belong to multiple communities, how they move from one community to another will enhance their success. Crossing border between communities is a necessary component to both learning and creating new possibilities for themselves in the identity formation process (Wenger, 1998). For the participants in this study, they belonged to the two communities of the STEM HBCU and science at large that they experienced when they participated in summer internships. Although African American students were fewer in numbers in some of these programs, the students who attended them received meaningful recognition such as the publication of their research. By being in other communities for a period of time, they developed practices that they brought back to their home schools. Furthermore, these practices increased their access to social capital as they cultivated networks of scientists and researchers from other STEM contexts. The participation in these internships further solidified their membership in a community of practice since the experiences allowed them to be recognized for their work.

### **Putting All the Puzzles Together: A Bridge to a College STEM Program**

Taken together, findings from this study highlights the salience of 1) pre-college experiences and contexts in developing a disposition to a STEM identity for underrepresented minority students as they move into a STEM college at a HBCU; 2) disciplinary knowledge in formulating STEM identity; and 3) complexities of identify formation in STEM program at HBCU.

Figure 2 presents the findings from this study by revisiting the adaptation of the model of multiple dimensions of identity (Abes, Jones & McEwen, 2007) from chapter one. Van Maren's (1990) lifeworld existentials provided a framework for generating an understanding the complexities of STEM identity formation for underrepresented minority students by the many layers of their lived experiences while recognizing how contexts continuously shape those emerging identities. In moving from one context to another, the individual's identity is influenced by the changing contexts while acknowledging that one existential cannot be understood in isolation of the other. At the center of this model is the core of the STEM identity surrounded by the meaning derived from their lifeworld experiences.



*Figure 2.* Interaction of Lifeworld Existentials and STEM Identity Formation

Adapted from Abes, Jones & McEwen (2007) with the authors' permission

**The K-16 pipeline or a river?** The importance of high schools in the college preparation process is affirmed by Adelman (2006) who stresses that the “academic intensity of the student’s high school curriculum counts more than anything else in one’s pre-collegiate history in providing momentum” (p. 5) for successful degree completion. McDonough and Gildersleeve (2011) concur about the significance of pre-college experiences when they call for a better understanding of how the interaction between individuals and structures play a salient role in the P-16 pathway that should be deemed a “long term systemic event” (p.59). All the participants in this study recalled pivotal experiences from high school that propelled them to the STEM program in the study. Those pre-college experiences also strategically positioned them to be viable candidates for the program. Their recollections about their experiences from high school to college fell into two categories: a) discipline knowledge; and b) authentic learning experiences.

**Growing discipline knowledge.** In STEM fields, strength in discipline knowledge is critical for students to progress to higher levels of math and science (Maltese and Tai, 2010). Jose recalls being selected to take Algebra I as a seventh grader after taking a placement test in middle school. Because of that beginning step, he was on track to take Calculus in high school. Being in an AP Calculus class enabled him to develop confidence and norms as an academic student. Supreme also took higher level math early in his high school career and continued to a college Calculus class at the local community college since his high school did not offer the course. Both Jose and Supreme explained that since they took those courses, they were much better prepared for the math rigor of the program.

Varelas et al (2012) recommend a theoretical framework to study underrepresented minority students in STEM contexts where the learning process is analyzed as a sociocultural interaction between content learning (CL) and identity construction (IC). The intertwining and constant negotiation of these two conditions offers students the possibility to engage with ideas in settings where they are “situated” (Lave & Wenger, 1991) as capable “doers of the discipline, i.e. mathematics and science” (Varelas et al., 2012, p. 325). As noted earlier in Chapter 4, seeing oneself as a doer of the discipline was reflected by Jason. He always “loved math” and whenever he looked up career ideas in high school, he was drawn to descriptions of jobs like engineering that required the tangible application of higher level math skills. Taking a physics class in high school answered his questions and addressed his curiosity about how things work, recognizing that “science explains some of those things” that he always wondered about. For Brianna, a high school physics class piqued her interest in science especially in the introduction to classical mechanics. Similar to Jason, she referred to her natural curiosity about how things work and decided she could “find answers to all the questions she had as a child” when she studied physics. Danielle’s also described herself as curious about science and always experimenting at home but it was her experiences in high school Honors Chemistry that gave her the opportunity see her herself combining science and creativity into a potential career. For Jose, Supreme, Jason, Danielle and Brianna, access to ideas and information combined with their own skills and strengths influenced their interest in math and science disciplines. Maltese and Tai (2010) confirm that early interest in math and science is an important indicator to matriculating in the field,

however, they recognize that those indicators are not enough to explain what other educational experiences influence their pathways beyond the initial interest.

**Becoming a doer in the field.** Another aspect of the theoretical framework suggested by Varelas et al (2012) adds more ingredients to the notion of identity. These researchers (Varelas et al, 2012) describe three intersecting identities related to underrepresented minority students in STEM fields: disciplinary identity, where students see themselves as doers in the field; racial identity, where students construct a STEM identity and try to understand how that coincides with their racial identity; and academic identity, where students develop practices, norms, and habits of mind marked by exploration and questioning. The participants described a discipline identity where they reported success and understanding with the information in math and science. When these students reported being one of a few minority students in higher level math and science classes, they demonstrated how race impacts STEM identity formation. As they transitioned from high school to the HBCU STEM program, these young men and women reported interacting with positive racial identities in the STEM field at a juncture where the participants also engaged in academic identity formation. The environment of a STEM HBCU offered a context for constructing racial identity along with discipline and academic identity confirming research (Van Camp, Barden & Sloan, 2010) that HBCUs offer something unique to their students, such as “the opportunity to develop their racial identity in a predominately Black environment” (p.245).

Supreme, Ashley and Precise, for instance, had the additional element of authentic STEM learning experiences in their trajectories from high school to college. These three participants described those experiences as allowing them to “see” themselves early in

those fields whether they were in a hospital setting or in a computer lab. These real-life experiences served as a springboard for these students in developing a discourse identity described as ways of using language and practices that are recognized by others (Gee, 2002). In other research, Gee (1989) compares discourse identity to an “identity kit” (p.9) which comes with “the appropriate costume and instructions on how to act” (p.9) echoing Wenger (1998) that learning “belongs to the realm of experience and practice” (p.225) that alters our identities. As these students are moving into fields where there is a paucity of non-White professionals, accumulating experiences and practices for developing an identity kit are valuable.

Maltese and Tai (2010) point to data in their research that most students make the decision about majoring in a STEM field before they leave high school, indicating the importance of formal as well as informal STEM experiences in relation to entering the STEM pipeline. The participants in this study were indicative of these results with only Jose and Danielle considering another major initially. By moving from their high school contexts to the HBCU STEM program, they entered into a close knit group of like-minded students who were required to work closely together. The nature of the program continued to provide them with knowledge and experiences toward their nascent identities by requiring that they commit to a STEM major from the start and engage in STEM research programs. Through the ongoing process of the STEM curriculum, interactions between students and educators and between peers and undergraduate research, the participants were enabled in their STEM identity formation. By requiring all students in the program to participate in undergraduate research internships, they moved into other settings that Brant calls “locations of possibilities” (Brandt, 2008, p.716) where



they accessed resources and social ties that strengthened their emerging identities by experiences such as presenting research and publication of their research. By navigating the STEM culture from one institution to another, the students linked their past with their futures and strengthened their outward trajectories into a STEM field.

### **Implications of the Study**

Based on this study, there are a number of realities to address with regard to underrepresented minority students in STEM fields. From the P-16 perspective, how environments and circumstances can enable or disable aspirations over time points to the sociocultural nature of learning. Attention to the experiences of underrepresented minority students is critical if we are to understand the barriers to success in certain disciplines. Beyond STEM content knowledge, recognizing that social and institutional forces can influence students' academic identities and do open or close doors to interest and aspiration is important. Identity construction is not a singular event but instead a complex process that occurs through day-to-day "micromoments" (Malone & Barabino, 2008, p.489) in contexts where students are interacting in social settings with each other and content knowledge. A "microclimate" (Aschbacher et al., 2009, p.578), that varies from one school to another, present students with a variety of differences in their experiences: counselors, science courses, teaching styles, academic peers, and other resources. These micromoments combined with microclimates add up to settings that are not neutral environments because they carry with them the historical and social markers of exclusion in a particular discipline. In academic disciplines that are perceived as being "hard" such as science and math, these day-to-day interactions take on even more significance since these experiences can be pivotal in engaging a student to see their

pathway to completion. When individuals reach an “identity impasse” (Marlone & Barabino, 2008), the journey down the river or through the pipeline is interrupted.

Looking at learning as situated (Lave & Wenger, 1991), these academically talented underrepresented minority students benefited from the psychosocial elements of the MASI program. For underrepresented minority students, less than 25 % of initial STEM aspiring students earn a four year a bachelor’s degree in four year (HERI, 2010). As STEM completion rates are low among all students attending college (Stolle-McAllister, 2011), these participants have reaped the benefits of a socially and academically integrated system that invested in their futures. The stories of these successful students is evidence that by establishing a close-knit learning community of like-minded individuals with many opportunities for mutual interaction, students can and will develop a strong sense of discipline identity. Other educational settings could also be successful by building a similarly supportive and interactive social setting.

This study also sought to consider the value of STEM social capital for students pursuing these disciplines. These students benefited from social capital that opened doors and led them to viable opportunities in their pre-college context. Their individual interests and academic strengths in their respective disciplines were cultivated over time through networks and norms of STEM study. When they applied to the STEM college in the study, that action was facilitated by what Stanton-Salazar and Dornbusch (1995) call an “institutional agent” (p.117), someone who was able to advocate or pass on valuable resources and information. Although there were examples of resources and support, it is difficult to know if this support was part of an “explicit and strategic agenda” (Stanton-Salazar, 1997, p. 15) or luck on the part of the participants. In discussing social capital

and how schools can do a better job of transmitting social capital to underrepresented minority students, schools would be more successful if their efforts were part of a well-defined and deliberate endeavor.

By accessing pre-college STEM experiences and course work, the students developed norms and behaviors that acted as a catalyst to their STEM dispositions and elevated their understanding of career choices. Once they made the decision to attend the program, they committed themselves to their identities as STEM students. The norms and behaviors of pursuing an interest in STEM courses were conveyed through school social capital prior to going to college. Strong high school preparation in STEM courses ranks as significant among successful STEM college underrepresented minority students (Palmer et al., 2011), the positive outcomes being the development of an academic culture and norms of study. In Putnam's *Bowling Alone* (1995) he predicted that because Americans were in fewer relational networks, that social capital for the collective good would be reduced. One of the unique features of this program is the potential for networking and continuing research that sustained the students' interests and commitment and their outward trajectories to future careers. However, can the unique features of this program be replicated to other contexts? Furthermore, since the strength of these students' pathways is partially a result of their academic preparation in high school, there would be a benefit to a stronger articulation of support from high school to such a STEM college addressing underrepresented minority students and resources.

### **Limitations of the Study**

As with all studies, there are several limitations. With a sample of seven students and highly subjective nature of data, it is difficult to establish reliability and validity of

information that was collected through the phenomenological approach. To ensure both, it is imperative that a high level of objectivity is necessary on the part of the researcher (Moustakas, 1994). In the methodology chapter, I set aside my previous experiences with the phenomenon. I also used member checks (Patton, 1998) so that the participants could verify my understanding of the points made during our interviews. Since phenomenology explores the lived experiences for a group of individuals (Cresswell, 1998), the self-reporting of participants is both a strength and weakness of phenomenology. To address that aspect of the methodology, I carefully selected the participants to ensure that their lived experiences were relevant to the study. Finally, I consulted with individuals who were experienced in qualitative research to discuss the data.

In order to acknowledge the many layers of experiences and contexts of underrepresented minority students matriculating in STEM fields, I examined the lifeworld of these participants through the phenomenological lens of the four existentials of time, space, body and relations described by Van Maren (1991). As this study is an examination of the participants' experiences over time and in a particular place, temporality and spatiality are useful categories for data analysis. Given the historical context of race in education in the United States (Jacobson, 1999), corporeality likewise provided a category for opening the discussion about race in education in general as well as in higher education and STEM disciplines. Finally, the category of relationality (Smerdon, 2014) acknowledged how the participants experienced relationships with others that acted as a catalyst to their STEM dispositions building trust, norms and communities. In using the four existentials, I was spotlighting one particular aspect of the

participants' experiences, analyzing the data from that perspective and then considering another one, recognizing that all four existentials are interwoven with each other.

In addition, because of the sample size, it is hard to generalize the findings. In other words, it is hard to know if the participants adequately represent the pathways of the students who choose to attend a STEM Honors college at a HBCU. Additionally, this institution is a public HBCU which would attract different kinds of students than a private HBCU or a religious HBCU so it is not necessarily generalizable to all HBCU STEM students. . Given the differences in the history, scope and size of HBCUs, it would be difficult to draw conclusions that apply to all institutions that have been designated as such. This study did not include a broad representation of STEM disciplines as there are nine majors that students came pursue in the program. The only majors represented in this study are chemistry, biology, physics and computer science. It could be fruitful to see if the experiences of students in other majors were similar to those interviewed in this study. This would have been interesting since the scope of the study was to identify a high school to college pipeline. Other STEM majors, such as engineering, are not well represented in high school curricula so their experiences and contexts could have been completely different. This study does not claim any universality to the findings, only to generality within the contexts that were studied.

The participants in this study came from their sophomore to senior years in the program. Given this broad range on the continuum of completion, their memories of high school experiences and coursework were varied. Since they were from different years, it is questionable if the value of their recall is equal. Although they all attended public schools, none of the seven participants came from the same high school so their high

school contexts were very different as well. Similarly, the demographics of all seven high schools were dissimilar. Another factor that was not considered was familial background. The purpose of the study was to focus on educational contexts so the omission was intentional. However, those factors such as parental encouragement or discouragement add to the complexity one's professional trajectory.

### **Closing Thoughts**

This study serves to form a launching pad to promote the insights garnered from this dissertation. The examination of the routes leading minorities to pursue STEM studies has not been conclusive, yet there is enough documentation to provide an impetus to those dedicated to increasing the numbers of underrepresented minority students in STEM fields. This clarion call will go unheeded unless the STEM gateways are institutionalized and led by enlightened leadership. To facilitate this kind of action, there must be forums for identifying and tracking those with the potential to pursue and succeed in this arena of academia. These forums must not only establish data bases of individuals possessing the prerequisite potential but also the tracking mechanisms that will be critical to the desired outcome. A parallel to the demand mechanisms that run financial markets must be found and inculcated within the school system that will serve to overcome the obstacles that have served to create the current milieu. The path ahead should include the development of partnerships between stake holders such as industry and educational institutions. Resources from partnerships can serve to leverage and solidify existing and future possibilities.

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**APPENDIX A  
LETTER OF APPROVAL**



**Office of Sponsored Programs**  
Marie V. McDemmond Center for Applied Research (MCAR), Suite 601  
700 Park Avenue, Norfolk, Virginia 23504-8060  
Telephone: (757) 823-9053- Fax: (757) 823-2823  
Web: <https://www.nsu.edu/sgsr/sponsored-programs/index>

April 8, 2014

Ms. Maria O' Hearn  
1012 Larchmont Crescent  
Norfolk, VA 23508

Re: *NSU IRB #13-39 - Approval*

Dear Ms. O' Hearn:

The Norfolk State University Human Subjects Institutional Review Board received your request for approval to conduct your "*At the College Gates: A Phenomenological Study of STEM Identity Formation at a Public HBCU*" research.

A review was conducted by the Committee and you were officially approved to conduct your study as of April 2, 2014. This approval will expire on April 1, 2015. Any required extensions must be processed through the IRB Committee, at least 45 days prior to this expiration. A copy of the approval and the Annual Reporting form, (due no later than one year from the date of this approval, or within two weeks of the completion of this research, whichever occurs first) is provided for your use. Additionally, any proposed changes to the protocol must be submitted to the IRB for review and consideration prior to implementation of the intended change(s), unless such a change is necessary to avoid immediate harm to subjects.

On behalf of the Institutional Review Board, I wish you the very best as you conduct this research and continued success in all your future endeavors.

Sincerely,

Paula R. D. Shaw  
Director

C Dr. Rowena Wilson, Chair, IRB  
Dr. Yonghee Suh  
Dr. Aliccia McClain

Attachments: Human Subject Institutional Review Board Form  
Institutional Review Board Annual Report Form

**APPENDIX B****REQUEST FOR PARTICIPANTS**

March 2014

Dear DNIMAS students:

I am a PhD candidate presently studying in the Curriculum and Instruction Program at Old Dominion University. I have also been a high school teacher for the past twenty years in Norfolk. The title of my research is "At the College Gates: A Phenomenological Study on STEM Identity Formation in Students Attending an Honors College at a Public HBCU". I am preparing to collect data for my research and would like to hear about your personal experiences in the educational pipeline.

If you are interested, please contact me at [mohea001@odu.edu](mailto:mohea001@odu.edu). Dr. McClain has kindly offered me the use of the conference room in the DNIMAS office so I can schedule the interviews at a time and location that is convenient for your needs. I am anticipating that the interviews will begin around the beginning of April.  
Thank you for considering this opportunity.

Sincerely,

Maria O'Hearn

## APPENDIX C

### INFORMED CONSENT

**Project Title:** At the college gates: A phenomenological study of STEM identity formation at a STEM Honors College at an HBCU

**Purpose:** The purpose of this form is to give you information that may affect your decision whether to say “YES” or “NO” to participation in this research and to record the consent of those who say “YES”.

**Project Description:** The purpose of this study is to generate an understanding of how students develop a STEM identity from high school to their present experiences in a STEM Honors College at a HBCU.

If you decide to participate, then you will join a study involving research of college students at HBCUs and their recollections of their pre-college and college experiences in developing their STEM identity. If you say “YES”, you will agree to participate in three interviews of approximately 60 minutes each. There will be seven students in this study.

**Confidentiality:** All information about you in this study is strictly confidential. The results of this study may be used in reports, presentations, and publications but the researcher will not identify you. You will select a pseudonym and that is how you will be identified.

**Withdrawal Privilege:** It is OK for you to say “NO”. Even if you say “YES” now, you are free to say “NO” later, and walk away or withdraw from the study at any time.

**Voluntary Consent:** By signing this form, you are saying that you have read this form and that you understand the research study, its risks and its benefits. The researcher should have answered any questions you may have had about the research. If you have any questions, please contact the researcher. Below is the researcher’s contact information:

Name: Maria O’Hearn

Phone number: 757-613-6460 (cell)                      E-mail: [mohea001@odu.edu](mailto:mohea001@odu.edu)

Mailing address: 1012 Larchmont Cres., Norfolk, Va 23508

If you have any concerns about this research project, please contact Dr. Yonghee Suh, the Responsible Project Investigator for this study, at [ysuh@odu.edu](mailto:ysuh@odu.edu) or Dr. Theodore P. Remley, Jr., Chair of the Darden College of Education Human Subjects Committee at [tremley@odu.edu](mailto:tremley@odu.edu).

Additionally, you may address any concerns to the Norfolk State University (NSU) Internal Review Board (IRB) committee chair, Dr. Rowena Wilson at [rgwilson@nsu.edu](mailto:rgwilson@nsu.edu) or at 757-823-8668.

The researcher will give you a copy of this form for your records.

I agree to give my consent to participate in the above study.

Name \_\_\_\_\_ Date \_\_\_\_\_  
(Subject’s printed name & signature)



**APPENDIX D****BIOGRAPHRAPHIC SURVEY**

Please answer the following background information questions about yourself. This data collection is confidential and will only be used by the researcher. Your name will be changed to a pseudonym in the study. Thank you.

1. Name \_\_\_\_\_
2. Email address: \_\_\_\_\_
3. Year of birth: \_\_\_\_\_
4. Parental education level:  
Mother: \_\_\_\_\_  
Father: \_\_\_\_\_
5. Name of high school you graduated from: \_\_\_\_\_
6. City and state of high school you graduated from: \_\_\_\_\_
7. Special programs you participated in when you were in high school-please circle (could be more than one):  
  
magnet school  
IB program  
vocational school  
gifted program  
advanced placement  
other \_\_\_\_\_
8. Organizations and/or sports you participated in high school and number of years:

9. Leadership positions you held in high school (for example, class president or captain of your softball team):
  
10. Year you graduated from high school: \_\_\_\_\_
  
11. GPA senior year of high school: \_\_\_\_\_
  
12. Year you started college: \_\_\_\_\_
  
13. Intended year of graduation from college: \_\_\_\_\_
  
14. Intended or declared college major: \_\_\_\_\_
  
15. GPA for most recent semester in college: \_\_\_\_\_
  
16. Special programs you belong to in college (such as honors college):
  
  
  
17. Organizations you belong to in college (clubs, community activities):

## APPENDIX E

### OPENING SCRIPT

Good afternoon. I am Maria O'Hearn and I am a doctoral student at Old Dominion University. Thank you so much for agreeing to allow me to interview you. I'd like to talk to you today about your STEM related experiences before college as well as your experiences since you have started pursuing a STEM major.

The focus of this study is to explore how underrepresented minority students developed a STEM identity from high school to college. I am interested in finding out your thoughts about your experiences as you recollect them. There will be three interviews that will take approx. 45-60 minutes each and the interviews will ask you to reflect on where you are right now in your academic pursuits and then think back on your personal path to arrive at this point.

I have a consent form here for you to sign. I have two copies-I will keep one and you may keep the other for your records, if at any time you feel uncomfortable, you may end the interview. Since I am doing this for research purposes, I am going to record the interview. I will transcript the information and when I finish doing do, I will destroy the audio file. Everything you say will be kept in confidence, Now, I'd like you to think of a pseudonym that I will use when I transcribe this interview. Do you have any questions?

## APPENDIX F

### INTERVIEW PROTOCOL

#### **Introduction:**

*Good morning/afternoon and thank you for agreeing to participate in these interviews. As you remember from our pre-interview discussion, I am investigating the experiences of students attending a STEM Honors College and the development of their STEM identities. Before we begin, let me remind you that I am recording this interview. If I ask you a question and you don't want to answer, let me know and we will move on. Do you have any questions before we begin? [Answer questions.]*

*OK, let us begin. We will start with talking about where you are currently and then in the subsequent interviews, I will ask you to reflect back on earlier experiences that influenced your STEM study.*

#### **I. Interview I-The essence of experience as a STEM major at a HBCU.**

*For the first interview, I'd like to get to know your thoughts about where you are now in your educational path as a STEM major.*

1. Tell me about what your semester was like at DNIMAS (Dozoretz National Institute for Mathematics and Applied Sciences).

Probes:

What happened? Describe for me what a typical week [or day] is like for you.

What was it like, being in the DNIMAS program, for you?

2. Before you enrolled here, what were your expectations of being a STEM major?

Probes:

Academically

Socially

3. How have your experiences and opportunities here met those expectations?

Probes:

What are some examples?

4. Why did you decide to become a STEM major?

Probes:

Do you remember when you thought about it?

A particular experience?

5. What do you like about being a STEM major? What do you dislike?

Probes:

Public perception?

Time demands?

## II. Interview II-Contexts in Constructing a STEM identity

*Good morning/afternoon. Nice to see you again. Before we move on, I'd like to summarize what we talked about during our first interview. Have your thought differently about anything we talked about? Anything you'd like to add? For this interview, I'd like you to think about contexts or environments where you developed a STEM identity.*

1. What was your experience like in high school?

Probes:

When did you become interested in science and/or math?

How was your interest piqued?

2. What were the math and/or science programs like in high school? What math and/or science programs did you participate in when you were in high school?

Probes:

How did you feel about these programs?

3. Describe the classrooms where you took math and science courses in high school.

Probes:

What was the student body like?

Who took the class with you?

How did you like the teacher?

How did you like the curriculum?

4. Was there any particular class, activity or experience in a science or math class that you still remember?

Probes:

Please describe that experience.

5. When you were growing up, what careers did you imagine for yourself?

Probes:

In STEM fields?

Other fields?

6. How do your family or friends see you or describe you? How do they feel about you being a STEM major?

Probes:

How do they describe you to others?

## III. Interview III- Negotiate Social Identities with STEM identity.

*As this is our final interview, I encourage you to add anything that you may have thought of that we have not discussed already. Every one of us has many different identities and those identities are dynamic and change with the circumstances. The focus for this interview is discussing the development of a professional identity, the processes that an*

*individual experiences in seeing themselves as a competent “doer” and member of their field and challenges along the way. Let's start with this excerpt from a magazine article I read recently in Parade magazine (Jan14, 2014) about the work of Neil deGrasse Tyson an astrophysicist who is presently hosting a TV series in March called Cosmos: A Space Time Odyssey. The interviewer describes Tyson's recollections of the early reaction to him as an African American interested in science: (participants will be given a copy of this part of the article to read)*

His parents also gave him his first telescope after a transformative childhood trip to the Hayden Planetarium, which he now runs. “Initially I thought it was a hoax,” he says of the space show he saw that day. “The sky over the Bronx just didn’t have that many stars.” That vision gave him purpose, a bold dream for a young black man at the time.

“I was an aspiring astrophysicist and that’s how I defined myself, not by my skin color,” Tyson says. But others did, in ways sadly familiar to many young African-American males. “People didn’t treat me as someone with science ambitions,” he says. “They treated me as someone they thought was going to mug them, or who was a shoplifter. I’d be in a department store and the security would follow me. Taxis wouldn’t stop for me. And I was just glad I had something to think about other than how society was treating me.” In school, he adds, “teachers would say, ‘You should join this or that team,’ not the physics club. My fuel tank had been stoked since I was 9, but it took some energy to overcome the resistance. I wondered if there was a lost generation of people who succumbed because their fuel tanks were a little smaller than mine.”

1. What are your thoughts on what Tyson said?

Probes:

About race?

About science?

2. Is your experience as a STEM major similar or different from Tyson’s?

Probe:

How important is race in your studies at MASI?

A significant factor?

3. What advice would you give an African American student considering being STEM major?

Probes:

In general?

Specific to your discipline?

4. What do you want to become after graduating from this program?

Probes:

A field of interest?

Continue to grad school?

An interim step?

5. How do you feel this program in particular will help you contribute to your field?  
Probes:  
Experientially  
Socially

*Thank you for taking the time to participate. Is there anything you would like to add about your experiences pursuing a STEM course of study at a HBCU?*





## VITA

### Maria V. O'Hearn

Department of Teaching and Learning, Education Building  
Old Dominion University; Norfolk, VA 23529

## EDUCATION

- |              |  |
|--------------|--|
| 2009-Present | Old Dominion University, Norfolk, VA<br>Ph.D. Candidate Education, 2014      |
| 1975         | Jacksonville University, Jacksonville, FL<br>M.A.T. Social Science Education |
| 1973         | Bishop's University, Lennoxville, Quebec<br>B.A. Political Science           |

## CERTIFICATION

**Postgraduate Professional License** in History and Social Science from Commonwealth of Virginia-continuous from 1990; current licensure 2012-2017

## EXPERIENCE

- |              |  |
|--------------|--|
| 1992-present | Teacher & Department Chair<br>Norfolk Public Schools |
| 1992-1988    | Adjunct Instructor<br>Old Dominion University        |

## PUBLICATIONS

- Hinton-Johnson, K., Suh, Y., O'Hearn, M. & L. Colon-Brown. Historical Fiction in English and History/Social Studies Classrooms: Is there a Natural Marriage of the Two Disciplines? Accepted to *English Journal*, November, 2013.
- O'Hearn, M. (2012, March 1). [Review of the book *Empowering the voice of the teacher researcher*, R. Brindley & Crocco, C. (Eds)]. *Childhood Education*, 88: 2, 132-135.
- O'Hearn, M. (2012, March 1). [Review of the book *35 Strategies for guiding readers through informational texts*, B. Moss & V. Loh]. *Childhood Education*, 88: 2, 132- 135.