ABSTRACT

WHITE, ANGELA MICHELLE. Understanding the Relationships Between the Racial Identity, Science Identity, and Science Self-efficacy Beliefs of African American Students at HBCUs. (Under the direction of Dr. Jessica DeCuir-Gunby).

In this study, the relationships between the racial identity, science identity, and science self-efficacy beliefs of African American college students who attend HBCUs have been explored through the utilization of a concurrent mixed methods design (QUANT + qual). The study was viewed through the analytic lens of Critical Race Theory (CRT), and specifically guided by the following CRT tenets: permanence of racism, challenge to dominant ideology, intersectionality, and whiteness as property. Approximately, 347 African American science students (Biology, Chemistry, Physics, and Pharmaceutical Sciences) participated in the quantitative aspect and 14 students participated in the qualitative component, the semi-structured interviews. The students were sophomores, juniors, or seniors and were enrolled at a southeastern HBCU.

The quantitative data showed that significant positive relationships were found between science identity, science self-efficacy beliefs, and racial identity. The number of college science courses taken was also significantly correlated with racial identity. In addition, the data revealed that the nationalist ideology (racial identity) moderated the relationship between science self-efficacy and college achievement. The qualitative data yielded several important findings. According to the shared experiences of the participants, interactions that they experience with other African American science students and faculty
promote the development of and interactions between their racial identity, science identity, and science-self-efficacy beliefs. Also, subtle acts of racism by White HBCU faculty or White principal investigators for their research experiences hindered a positive interaction between their science identity and science self-efficacy; thereby, supporting the notion of the permanence of racism. In addition, findings revealed that African American students at HBCUs prefer Black spaces, but their interactions with non-African American faculty at their HBCUs or interactions in other predominantly White settings require that they strategically assimilate. The need to strategically assimilate, despite a strong sense of racial pride and predominately Black educational context, reveals how science-related activities reinforce the notion of “Whiteness as property”.

Keywords: self-efficacy, science identity, racial identity, critical race theory, HBCU, African American
Understanding the Relationships Between the Racial Identity, Science Identity, and Science Self-efficacy Beliefs of African American Students at HBCUs

by

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DEDICATION

I dedicate this dissertation to the Lord who is the one who downloaded the ideas and aroused the passion for this study. It would have been virtually impossible for me to have endured the various stages of this dissertation without His grace and continual guidance. I give back to you what you have birthed through me.

I dedicate this dissertation to the many African American students who seek to become scientists. Rest assured that each one of you are surrounded by a great cloud of witnesses, so lay aside every weight that slows us down (i.e. negative stereotypes, the low self-efficacy, the doubt, etc.) and run with endurance the race God has set before you!
BIOGRAPHY

Angela Michelle White was born and raised in Greensboro, North Carolina. She is the daughter of Michael White Sr. and Nora White. Her love for math and science guided her to the University of North Carolina at Chapel Hill, where she earned a Bachelor of Science in Biology in 1999. After working for two years in Chapel Hill, Angela returned home to Greensboro to further cultivate her science knowledge and technical skills. In 2004, she graduated with her Master of Science in Biology from North Carolina Agricultural and Technical State University. Her educational training in biology entailed research experiences in virology at the University of Maryland at College Park, as well as in cancer biology at Wake Forest University.

Such educational and research experiences not only equipped for a career as a biologist, but also activated a passion for teaching. Thus, Angela has served as an educator for 13 years at various levels, and trained science teachers across the nation. She taught for biology for three years at T. Wingate Andrews High School, as well as anatomy and physiology at Guilford Technical Community College for five years. Additionally, she worked as a product developer for Carolina Biological Supply Company for several years, and has continued to work with the company as a consultant/teaching partner. Currently, she is a full-time lecturer and the Coordinator of Science Initiatives for the Department of Biology at North Carolina Agricultural and Technical State University. She is in her seventh year of employment at North Carolina A&T, and is even more passionate about the success
of African American students in STEM today than she was when she first began teaching at the university.

Above all, Angela deeply loves the Lord and has always sought to position Him at the center of every decision, especially her professional and educational involvements. Not only has her passion for teaching been displayed within our secular educational system, but it has also been displayed within the four walls of the church. She was licensed as a minister of the gospel in 2006 and ordained as a pastor in 2016. Angela is an associate pastor at the Headquarters of a Church Without Walls, where she has been a disciple for five years. She serves as the Director of Lay Teachers, which allows her to impart the knowledge that she has acquired over the years as an educator and most recently through her doctoral program into individuals in the body of Christ who are called to teach the word of God.
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Eddie Redmon, thank you for your love, support, and for prophetically speaking the outcome of Dr. White into existence.

I would like to thank my committee members who went above and beyond the call of duty throughout this entire process. I feel so blessed to have such a unique assembly of scholars who have actively cultivated the educational psychologist within me. Thank you for sharing your expertise and for sacrificing your time. A very special thank you to Dr. Jessica DeCuir-Gunby, my committee chair for your instrumental guidance, encouragement, and patience. Your mentorship has shaped me into a better researcher and cleared my vision to see through a more critical lens. I have been able to glean from you in this “field” just as Ruth was able to glean from Naomi…Thank you for every deposit that you made along the way. Thank you Dr. Nietfeld for agreeing to serve on my committee, but most of all for mentoring me from the moment I took your Advanced Educational Psychology class. Thank you Dr. Hope, Dr. Sondel, and Dr. Davis for serving on my committee, and for providing me the feedback that sharpened the focus of my study.

Gaining access to the students who participated in this study would have not been possible without the assistance of various points of contact at several historically Black colleges and universities; therefore, I dedicate this work to each one of you. I dedicate this work to my colleagues at my employing institution who fostered many of the connections, assisted with recruitment, and encouraged me throughout my dissertation journey. To Dr. Cailisha Petty and Dr. Grace Byfield, thank you for challenging me to say “No” and covering
me during this very critical timeframe. I am blessed to have the two of you on my side. Cailisha - the support that you provided was selfless and served as a true indicator of character and friendship. Thank you for being my shoulder to cry on, a voice of wisdom, and my forerunner. To Dr. Hope Jackson and Dr. Jawanna Southerland-Little, I could not have asked for greater forerunners than the two of you. Thank you for paving a path into the academy that I could feel safe traveling along. The strategic check-ins were a God-sent and came right at moments when I needed a boost in my faith or direction for a critical decision. Thank you for the consistent assistance that you two have provided from the beginning of my doctoral matriculation up to this very moment. To Dr. Dinitra White, Dr. Kelsie Bernot, Dr. Checo Rorie, Dr. Roy Commans, and Dr. Robert Newman, thank you for supporting and encouraging me throughout this process. To Dr. Mary Smith, thank you for granting me the flexibility that I needed to finish this massive undertaking. I am blessed to have a department chair that genuinely wants the best for me and believes so strongly in what God has placed within me. You have been a great mentor!
TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................... xi
LIST OF FIGURES ........................................................................................................... xii
CHAPTER I: INTRODUCTION ......................................................................................... 1
  Theoretical Framework ............................................................................................... 3
  Inquiry Worldview ................................................................................................... 4
 Central Tenets of CRT .............................................................................................. 6
  Permanence of Racism ............................................................................................ 8
  Challenge to Dominant Ideology ........................................................................... 8
  Voices of people of color/Counterstorytelling ...................................................... 10
  Intersectionality ....................................................................................................... 11
  Whiteness as property ........................................................................................... 12
 Substantive Content Theories .................................................................................. 16
 Subjectivity Statement ............................................................................................. 21
 Purpose Statement .................................................................................................... 27
 Statement of the Problem ......................................................................................... 27
 Goals of the Research ............................................................................................... 28
 Mixed Method Rationale ........................................................................................... 28
 Significance ................................................................................................................ 29
 Operationalization of Terms ..................................................................................... 30
 Overview and Organization of Dissertation ......................................................... 31

CHAPTER II: LITERATURE REVIEW ........................................................................... 33
 Identity Theories and Identity Development ............................................................ 33
 Social Identity Theory and Identity Theory ............................................................. 36
 Triple Quandary Theory .......................................................................................... 40
 Racial Identity ........................................................................................................... 42
  William Cross and Nigrescence Theory ............................................................... 44
  Multidimensional model of racial identity ............................................................. 46
 Science Identity ......................................................................................................... 49
 Self-efficacy and Science Self-efficacy ................................................................. 56
 The Mechanism of Personal Agency ....................................................................... 59
 Sources of Self-efficacy ............................................................................................ 60
  Performance accomplishments/mastery experiences ......................................... 61
  Vicarious experience ............................................................................................... 61
  Verbal or Social persuasion .................................................................................... 62
  Physiological and affective states ......................................................................... 63
 Self-efficacy and Context ....................................................................................... 64
 The Role of Historically Black Colleges and Universities (HBCUs) .................... 67
 Chapter Summary ..................................................................................................... 74
LIST OF TABLES

Table 1  CRT tenets: Descriptions and Literature sources .............................................................. 7
Table 2  Frequency Table for Major School, Highest Science in High School, and Highest Math in High School .............................................................. 82
Table 3  Description of Participating Institutions ........................................................................ 85
Table 4  Reliability Table for Science Identity, Science self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard ................................................ 87
Table 5  Interview Participant Profile .......................................................................................... 91
Table 6  Means and Standard Deviations for Continuous Variables ........................................... 97
Table 7  Sample Display of Quantitative and Qualitative Findings Table ................................... 104
Table 8  Regression Results with Centrality and Science self-efficacy ....................................... 110
Table 9  Regression Results with Public Regards Mediating the Relationship Between College Science GPA and Science self-efficacy ........................................ 110
Table 10 Pearson Correlation Matrix among Science Identity, Science Self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard ............................. 111
Table 11 Linear Model Comparison Table between the Non-Interaction and Interaction Model ........................................................................................................ 116
Table 12 Moderation Analysis Table with College Achievement Predicted by Science self-efficacy Moderated by Nationalist .................................................................... 117
Table 13 Regression Results with Science Identity Mediating the Relationship Between College Achievement and Science Self-efficacy ...................................... 119
Table 14 Correlations for High School GPA, College Science Courses, College Science GPA, Science Identity, Science Self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard ................................................................. 122
Table 15 Meta-themes, Sub-Themes, and CRT Connection ......................................................... 123
Table 16 Sample Paired Comparison of Quantitative and Qualitative Findings ......................... 145
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Model of science identity (Carlone &amp; Johnson, 2007)</td>
<td>53</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Interdependent relationship between the interacting determinants</td>
<td>59</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Gist-Mitchell Proposed Model (1992)</td>
<td>64</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Schematic of Concurrent Mixed Methods Design</td>
<td>77</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Schematic of research hypotheses</td>
<td>80</td>
</tr>
</tbody>
</table>
CHAPTER I: INTRODUCTION

Traditionally, science and science-related careers were designated as privileges for the White elite, specifically White males (Russell & Atwater, 2005). In fact, over 50% of the scientists and engineers working in industry are white males, while white women account for another 25% (Falkenheim & Burrelli, 2012). There are a number of school practices and policies that have maintained the structure of hegemony that exist within the American educational system. Over the years, African American students have not experienced great success in science and are greatly underrepresented in science courses and science-related careers (Russell & Atwater, 2005). African Americans are considered underrepresented in science because the percentage of African Americans with science degrees and working in science-related careers is dramatically lower than the percentage of African Americans in the U.S. population; however, whites and Asians are overrepresented (NSF, 2013; Fries-Britt, S., Younger, T., Hall, W. 2010; Lewis, B. & Connell, 2005; Russell, 2005).

Even though science and engineering positions are becoming increasingly available, fewer African American students are persisting through science disciplines to obtain these positions (Russell and Atwater, 2005). In fact, the percentage of African Americans who have received science degrees has remained relatively constant since 2002 (NSF, 2015). According to the Science and Engineering Indicators 2008, approximately 34% of African American students intended to major in science, technology, engineering, and mathematics in 2006. This percentage is higher than the percentage of incoming White freshman (29.5%)
that intended to major in science or engineering. Research conducted by the National Science Foundation (NSF) showed that the college graduating class of 2013 consisted of 74.8% White, 8.4% Asian, 7.5% Hispanic, and 7.1% African American (NSF, 2015). Additionally, NSF (2015) reported that the participation rates of White graduates in science and engineering careers was 69.9%, while the participation rates for African Americans in science and engineering careers was 4.8%. These numbers indicate that African American students have a desire to pursue degrees and careers in science at rates comparable to White students; however, there is a turn of the tide when it comes to the numbers who actually obtain science degrees and positions in the field. To this end, African Americans are not experiencing the careers that typically provide the greatest opportunities for financial prosperity and professional status. If African American students intend to major in science disciplines at higher rates than their White counterparts, then why are there so few African American students who receive a science degree and enter science-related careers? In order to address this question, one must consider that African American students in science face the challenge of navigating their way through a system that is characterized by White, male values and behavioral norms (Carlone & Johnson, 2007).

There is a gap in the literature as it relates to the persistence of African American students in science fields of study (Russell & Atwater, 2005). The purpose of this study is to investigate various factors that potentially influence the science achievement of African American students. Specifically, this study takes a deeper look into the relationship between
the racial identity, science identity, and science self-efficacy beliefs of African American students. Moreover, this investigation is situated within the context of historically Black colleges and universities (HBCUs), as they have a disproportionately higher number of graduates with science degrees (NSF, 2013; Shorette & Palmer, 2015). Between 2006-2010, close to 35% of the doctorates earned by African Americans in science and engineering were granted by HBCUs. Unfortunately, HBCUs only represent a small percentage of institutions of higher learning in the United States.

**Theoretical Framework**

Education researchers and science educators have posited the influence of many different cognitive and psychological factors and frameworks to explicate the underperformance and underrepresentation of African American students in science. For the most part, these theoretical constructs have been maintained as isolated ideas, without extensive consideration of their relationship to each other. The theoretical framework utilized in this dissertation synthesizes the isolated theoretical constructs into one comprehensible framework. The substantive theories of this framework include *social cognitive theory* (Bandura 1977a, 1977b, 1986), *situated-mediated identity theory* (Murrell, 2007, 2009), *science identity theory* (Carlone & Johnson, 2007) and *Multidimensional Model of Racial Identity* (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Through the inclusion of the aforementioned theories into this theoretical framework, I have generated a model that conceptualizes the relationships between racial identity, science identity, and science self-
efficacy beliefs. In addition to the aforementioned substantive content theories, this study has been informed by the central tenets of my inquiry worldview of Critical Race Theory.

**Inquiry Worldview.** My research study was situated within a critical, interpretive framework. More specifically, my work was guided by Critical Race theory (CRT) which centralizes race at the core of analysis (DeCuir-Gunby & DeVose-Walker, 2013). There is not a concept as complex and contentious in sociological thought than that of race (Winant, 2000). When seeking to understand the experiences of marginalized or underrepresented groups with regard to race, gender, sexuality, or class, an interpretive lens is an appropriate choice (Creswell, 2007). Moreover, utilization of an interpretive lens may potentially provoke a call to action and change (Creswell, 2007). Critical Race Theory (CRT) is an interpretive framework that emphasizes the experiential knowledge of racial minorities and their communities as it relates to race and race relations (Delgado & Stefancic, 2012). A unique quality of CRT is that it takes into consideration that race and racism are focal constructs that have intersected with various dimensions of a person’s identity such as gender, sexuality, and social class (Crenshaw, 2011).

Critical Race Theory evaluates racism as both an individual and group experience that operates on multiple levels, and approaches this phenomenon as being heavily woven into the fabric of American society. Thus, utilizing CRT as a theoretical framework requires that the researcher place race and racism at the forefront of every aspect of the research process (DeCuir-Gunby & Dixson, 2004). Critical Race Theory can be used as an analytic and
theoretical lens to evaluate the relationships between racial identity, science identity, and science self-efficacy beliefs. Moreover, it can be used to analyze the ways African Americans students’ perspectives of their college experiences at HBCUs influence their racial identity, science identity, and science self-efficacy beliefs.

CRT draws its origins from critical legal studies (CLS), as it emerged in the 1970s as a more radical approach to addressing the collective racialized experiences of people of color (Delgado & Stefancic, 2012; Parker, 2015). While CLS served as the forerunner of CRT, many of the early CRT scholars criticized its failure to acknowledge the role the law played in the history of racism in American society (Cook, 1995; Crenshaw, 1988). Critical legal studies scholars did not include critiques of racial power in their analysis or theories, thus at times their writings could not be distinguished from those of the dominant institutions that they challenged (Crenshaw, Gotanda, Peller, & Thomas, 1995). Thus, a group of scholars and students assembled to construct an “alternative account of racial power and its relation to law and antidiscrimination reform” (Crenshaw, Gotanda, Peller, & Thomas, 1995, p. xxi). A key goal of CRT is to enhance society’s understanding of racial power from a position on race that is not aligned in any way with liberalism (Crenshaw, Gotanda, Peller, & Thomas, 1995).

Significantly, CRT underscores the socially constructed nature of race, and asserts that racism is a permanent feature of our nation (Delgado & Stefancic, 2012; Dixson, 2006; Gotanda, 1991; Ladson-Billings & Tate, 1996). Interestingly, most people in America fail to
see that racism has been institutionalized and systematized; thus, they only consider it to be an individual and senseless act (Savas, 2014). To this end, we can no longer restrict racism to the level of the individual for this causes us to overlook the manner in which racism operates within society and its institutions. CRT contends that racism is very much present in our society, but it has taken on a more subtle form that differs from what was experienced in the past (Delgado & Stefancic, 2012; Dixson, 2006; Ladson-Billings & Tate, 1996).

**Central Tenets of CRT.** Delgado and Stefancic (2012) point to the following central tenets of CRT: (1) permanence of racism, (2) a critique of liberalism, (3) the use of storytelling/counter storytelling – voices of people of color, (4) structural determinism (5) interest convergence and (6) intersectionality with regard to race, sex, and class (see Table 1 for descriptions and sources). Moreover, CRT argues against colorblindness, seeks to dismantle the myth of meritocracy, and counter dominant legal assertions of equality (Delgado & Stefancic, 2012); therefore revealing how these concepts synergistically create an interest convergence where people of color gain some advantages but not without Whites gaining something in return (Bell, 1992; Parker, 2015). In order to superimpose the experiences of people of color over the widely accepted dominant discourse, CRT theorists have strategically utilized fictional dialogues, stories, and personal testimonies in the form of counterstories (Delgado & Stefancic, 2012; Parker, 2015). One dimension that distinguishes CRT from other theoretical frameworks is that of activism. CRT scholars do not just seek to reveal racialized activities and structures within our society, but to also radically transform
There were several CRT tenets that guided this study in a more salient manner than others. For this reason, I will provide a more detailed discussion of the following tenets:

**Table 1. CRT tenets: Descriptions and Literature sources**

<table>
<thead>
<tr>
<th>CRT Tenet</th>
<th>Description</th>
<th>Literature Sources</th>
</tr>
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<tbody>
<tr>
<td>Permanence of racism</td>
<td>The notion that racism is a normal part of American society – racism is ordinary, not aberrational</td>
<td>Bell, 1992; Bell, 1995; Cook, 1990; Crenshaw, 1988; DeCuir-Gunby &amp; Dixon, 2004; Ladson-Billings &amp; Tate, 1995; Lawrence, 1995; Delgado &amp; Stefancic, 2012; Peller, 1995</td>
</tr>
<tr>
<td>Challenge to Dominant Ideology</td>
<td>Criticizes or challenges claims of meritocracy in society, the colorblind paradigm, incremental change, and neutrality law</td>
<td>Cook, 1990; Crenshaw, 1988; DeCuir &amp; Dixon, 2004; Freeman, 1995; Gotanda, 1991; Ladson-Billings &amp; Tate, 1995; Delgado &amp; Stefancic, 2012; Yosso, Solorzano &amp; Parker, 2002</td>
</tr>
<tr>
<td>Voices of people of color</td>
<td>The lived racialized experiences of people of color are captured through counter storytelling and counter-narrative; aims to cast doubt on the validity of widely accepted myths/messages (in particular those held by the majority)</td>
<td>Bonilla-Silva, 2002; Cook, 1990; Delgado &amp; Stefancic, 2012; Matsuda, 1995</td>
</tr>
<tr>
<td>Structural determinism</td>
<td>Widely shared practice dictates significant social outcomes; Due to the structure of certain systems some problems will not be resolved</td>
<td>Delgado &amp; Stefancic, 2012</td>
</tr>
<tr>
<td>Interest convergence or material determinism</td>
<td>The interests of people of color will only be granted when they converge with the interests of Whites – mutually beneficial. The Fourteenth Amendment does not provoke a judicial solution leading to effective racial equality for blacks when the solution poses a threat to the superior social status of whites Example: Brown v. Board of Education</td>
<td>Bell, 1980; Bell, 1995; Delgado &amp; Stefancic, 2012</td>
</tr>
<tr>
<td>Intersectionality</td>
<td>Explores the intersecting roles of race, sexuality, gender, class</td>
<td>Delgado &amp; Stefancic, 2012; Crenshaw, 2011; Gilborn, 2015; DeCuir-Gunby &amp; Dixson, 2004; Haney-Lopez, 2006; Harris, 1995; Leong, 2013</td>
</tr>
<tr>
<td>Whiteness as property</td>
<td></td>
<td>DeCuir-Gunby &amp; Dixson, 2004; Haney-Lopez, 2006; Harris, 1995; Leong, 2013</td>
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permanence of racism, challenge to dominant ideology, voices of people of color, intersectionality, and whiteness as property.

*Permanence of racism.* Critical Race Theory rests on the premise that racism is intricately woven into the fabric of American society. According to Derrick Bell (1992, 1995), racism is endemic and permanent in America; therefore, Black people will never experience equality in the United States. Despite civil rights movements, periodic victories in legislatures, and the Black Lives Matter movement, African Americans are in no way equal to whites (Bell, 1995). Moreover, any successes or victories are temporal due to the manner in which racial patterns adapt to sustain white dominance (Bell, 1992). While Jim Crow has been brought to an end, the white social norm still exist within popular consciousness and negative stereotypes associated with African Americans are still prevalent (Crenshaw, 1988). For these reasons, Bell (1995) asserts that racial equality is not a realistic goal. In order to embrace this CRT tenet, Bell (1995) suggest engaging in “Racial Realism”; therefore, taking into consideration the role that racism has played in American history. According to Bell (1995), the concept of Racial Realism allows African Americans to understand and appropriately respond to their subordinate status. Crenshaw (1988) asserts that racism and subordination are permanent in American due to the acceptance of a colorblind perspective. More specifically, the nation will never be able to correct subordination because it will never acknowledge its existence.

*Challenge to dominant ideology.* Critical race theory seeks to reinstate the radical
tradition of race-consciousness amongst African Americans by investigating the manner in which race and racism have been negotiated in American consciousness (Crenshaw, Gotanda, Peller, & Thomas, 1995). Critical race theorists posit that such a tradition of race-consciousness was rejected as integration, assimilation and colorblindness became the accepted norms of explanations related to race (Bell, 1995; Crenshaw, Gotanda, Peller, & Thomas, 1995; Delgado, 1995). For this reason, an essential tenet of CRT is to challenge dominant ideologies such as meritocracy, incremental change, colorblindness, and neutrality of the law. Moreover, a critical race methodology uncovers deficit-informed investigations that silences and misrepresents epistemologies of people of color (Delgado Bernal, 1998; Solórzano & Yosso, 2002). Derrick Bell (1995) asserted that the drive of establishing race balance (integration), as demonstrated in Brown v. Board of Education, blinded key judicial players from identifying the true factors that prevented African American children from receiving a quality education. Moreover, Bell (1995) introduced a more race-conscious point of view regarding Brown, thereby causing individuals to consider the impact integration had on the Black community.

On the surface, colorblindness and neutrality appear to be reasonable means to establish equal opportunities for all racial groups; however, they should be rendered insufficient given the fact that historically rights in America were heavily based on race (DeCuir-Gunby & Dixson, 2004). For this reason, adopting a colorblind ideology “ignores historical-race and the cumulative disadvantages that are the starting point for so many Black
citizens” (Gotanda, 1991, p.47); thereby, weakening the effectiveness of any possible solution. An end goal of colorblindness is a racially assimilated society that renders race irrelevant; thereby, neglecting the positive aspects of race (Gotanda, 1991). Such a goal of assimilation devalues Black culture and destroys positive facets of Blackness (Gotanda, 1991). According to Gotanda (1991), the assimilationist ideal associated with a colorblind society lends to the notion that one day the phenotypic aspects associated with race (i.e. skin complexion, hair texture, facial features, etc.) would be socially inconsequential.

Many of the CRT critiques of racial power unveil the manner in which various conceptions of merit operate not as a neutral basis for allocating resources and opportunities, but as a storehouse of hidden, race-specific preferences for the individuals who possess the power to make determine the connotation of “merit” (Crenshaw, Gotanda, Peller, & Thomas, 1995). Furthermore, Crenshaw (1988) emphasizes that America’s embracing of indecisive rhetoric of neutrality and equal opportunity law has made it very challenging for African American people to name their reality.

Voices of people of color/Counterstorytelling. While CLS critique of liberalism was accurate, it was not rooted in the lived experiences of those who experienced oppression; therefore, early crits rendered the critique incomplete (Cook, 1995). According to Matsuda (1995), the individuals who have directly experienced racism or discrimination speak with a unique voice that should be heard. Matsuda’s recommendation of “looking to the bottom” or embracing the perspectives and lived experiences of the least advantaged helped to shape the
CRT tenet of counterstorytelling. Instead of scholars making attempts to recreate the experience of life at the bottom of the totem pole, listening to the individuals who are positioned at the bottom provides a greater opportunity to connect theory to concrete experiences of oppression (Matsuda, 1995). The voices of the people promote an experiential deconstruction of systems and structures that have supported hegemonic ideologies (Cook, 1995).

According to Delgado and Stefancic (2001), counterstorytelling is a method of telling an account that “aims to cast doubt on the validity of accepted premises or myths, especially ones held by the majority” (p. 144). This methodology functions to uncover normalized discourse that propagate racial stereotypes, challenge privileged dialogue, and amplify the voice of marginalized groups (DeCuir-Gunby & Dixson, 2004). Majoritarian stories are constructed in such a way that they make racial privilege appear natural as they stem from a long legacy of racial privilege (Solórzano & Yosso, 2002). By employing counterstorytelling in this study, I will analyze the experiences of the fourteen participants and explain how their respective HBCUs promote the development of their racial identity, science identity, and science self-efficacy beliefs. Moreover, their lived experiences will shed light on how their experiences at PWIs or predominantly white science environments interrupted or limited such development or interactions.

Intersectionality. Identity consists of multiple dimensions that may be subjected to domination such as race, class, gender, and sexual orientation. For this reason, the tenet of
Intersectionality was introduced by Kimberlé Crenshaw (1995) in an effort to explicate the oppression and violence experienced by women of color. Under this tenet, a Black woman may be oppressed as a result of her race or because of her gender (Delgado & Stefancic, 2001). Early feminist and antiracist discourse did not take into consideration intersectional identities, thus Crenshaw (1995) sought to explore the intersecting patterns of racism and sexism. In doing so, Crenshaw (1989) centered Black women in her analysis in an attempt to investigate the multidimensionality of the experiences of Black women; thereby, removing the single-axis analysis that tends to distort such experiences. Crenshaw (1989) asserts that the utilization of a single-axis framework lends to the marginalization of Black women, as antiracist policy and feminist theory do not accurately reflect the interaction of race and gender. Thus, any analysis or investigation of Black females that is not guided by intersectionality cannot effectively address the specific manner in which Black women experience subordination (Crenshaw, 1989).

_Whiteness as property._ Early legal cases provide evidence that race is not only socially constructed, but that law is the primary contributor to its formation (Haney-Lopez, 2006; Harris, 1993/1995). The law enforced a form of differential treatment determined by racial categories such that blacks were not able to travel without permits, own property, gather in public settings, own weapons or acquire knowledge through formal education (Harris, 1993, 1995). Furthermore, black racial identity translated into those who were subjected to enslavement, while white identity labeled those who were “free” (Harris, 1993,
1995). In 1790, Congress restricted naturalization to “white persons”, and this racial prerequisite to citizenship stood until 1952 (Haney-Lopez, 2006; Harris, 1993, 1995). Being a white person was a condition for citizenship, thus many individuals sought to prove their “whiteness” through the United States judicial system (Haney-Lopez, 2006). To this end, the courts established criteria for which they drew boundary lines around “whiteness” (Haney-Lopez, 2006). Whiteness presented its owners with facets of citizenship, which became extremely valuable because they were denied to those who were not identified as white (Harris, 1993, 1995). According to Haney-Lopez (2006), the courts have not only marked the boundaries of race, but determine the substance of racial identities and denote their associated privilege or disadvantage in American society.

Harris (1993, 1995) explains that the development and maintenance of racial and economic subordination in America is due to the interaction between the conceptions of property and race. First and foremost, black labor was highly exploited because black people were treated as property (Harris, 1993, 1995). Most significantly, Harris (1993, 1995) postulated that whiteness is a form of property that is protected by American law. Harris (1993, 1995) developed the central CRT tenet of whiteness as property on the larger historical conception of property, in that, property is anything to which man has ascribed a value and have a right. Harris (1993, 1995) suggests that since whiteness legally defined a person’s status as slave or free, white identity bestowed palpable and economically valuable benefits. Expectations are considered to be a component or derivative of property, which is
protected by law (Harris, 1993, 1995). Specifically, the law safeguards one’s expectations of rights as legal property (Harris, 1993, 1995). Thus, “in a society structured on racial subordination, white privilege became an expectation” (Harris, 1995, p. 281); therefore, whiteness became fortified as property for personal identity. Since the law acknowledge and protected expectations rooted in white privilege, such expectations became property that could not be infringed upon without permission from the owner(s) (Harris, 1993, 1995).

According to Harris (1993,1995), the property functions of whiteness include: the right to transfer, the right to use or enjoyment, and the right to include or exclude others. There are modern conceptions of whiteness as property that continue to permit exclusion, such that predominantly white institutions continue to monitor the boundaries of whiteness through the synthesis of racial categories to which others are demoted (Leong, 2013). By embracing the principle of colorblindness, the Supreme Court and other systems safeguard the property interest in whiteness by shielding the status quo of distribution of social resources (i.e. goods, status and privilege) (Leong, 2013).

With regards to using CRT as a theoretical framework and analytic tool to examine African American students’ experiences with self-efficacy, science identity, and racial identity in the HBCU context, race and racism was placed at the foreground of every aspect of the research process. Specifically, CRT was applied to generating the research questions, methodology, data collection, data analysis, and presentation of the findings. Additionally, the central tenets of CRT drawn from Crenshaw (2011) and Delgado & Stefancic (2012)
were employed to frame my interview protocols and guide data analysis. When writing the interview protocol, the guiding questions were based on the centrality of experiential knowledge of the students in the study, the recognition that race is a part of their daily lives, and the CRT goal of social justice.

There is a lot of debate amongst CRT scholars over the appropriateness of using quantitative methods to explore research questions related to African American students, as CRT places great emphasis on the gaining a deeper understanding of the lived experiences of African American students (DeCuir-Gunby and DeVose-Walker, 2013). However, one’s perspective suggests that “critical quantitative approaches allow for the telling of ‘group’ or composite counterstories, although through the use of numbers, and are therefore compatible with CRT” (DeCuir-Gunby and DeVose-Walker, 2013, p. 248).

According to DeCuir-Gunby and DeVose-Walker (2013), mixed methods approaches are highly effective approaches to traditional research designs. Specifically, combining CRT with mixed methods should take place in the form of transformative-emancipatory frameworks, as they have the ability to challenged power issues and structures (DeCuir-Gunby and DeVose-Walker, 2013). A strongly suggested approach suggested by DeCuir-Gunby and DeVose-Walker (2013) is an explanatory mixed methods design (quant --> QUAL), with more emphasis being placed in the qualitative component of the study. While my current design places greater emphasis on the quantitative component, I have ensured that my designed is aligned with DeCuir-Gunby and DeVose-Walker’s suggestion to capture the
personal experiences of the students that explain the data from the quantitative portion of my study.

**Substantive Content Theories.** In addition to my study being guided by CRT, my work was also guided by several other theories. One such theory is social cognitive theory (Bandura, 1977a, 1977b), which stems from the work of Albert Bandura. Social cognitive theory is a psychological model of behavior that was initially designed to evaluate the acquisition of various social behaviors (Bandura, 1977, 1986). At present, social learning theory proposes that much of what an individual learns occurs within a social context and is gained primarily through observation (Bandura, 1977a, 1977b, 1986; Pajares, 1996). According to Bandura (1977a; 1986), people are able to regulate the direction of their lives by selecting and creating environmental supports for who and what they desire to become. Moreover, social conditions serve as the underpinning for human functioning, with environmental supports being established both by the individual and through collaboration with other (Bandura, 1977, 1986).

Bandura’s social cognitive theory is grounded within an infrastructure that consists of several key assumptions. One of the primary assumptions is triadic reciprocity, which posits that how an individual operates is the output of a continual interaction between cognitive, behavioral, and contextual factors (Bandura, 1977a, 1986). Essentially, an individual is able to make contributions that secure desired outcomes by enlisting cognitive guides, as well as by selecting and/or establishing environmental conditions that suit their
goals (Bandura, 1977, 1986). Self-efficacy beliefs are situated within triadic reciprocality, as it serves as a mediator between an individual’s thoughts and the actions carried out within a particular environment (Pajares, 1996). According to Bandura (1977, 1986), self-efficacy beliefs, an individual’s judgments of personal capability, serve as highly reliable predictors of behavior. A second assumption that people possess an agency to regulate their own behavior, as well as the environment is a very goal-oriented manner (Bandura, 1986, 2001). Thus, while people are not the sole determiners of the events that take place throughout their life journey, they are key contributors. Social cognitive theory does not disregard the influence exerted by the environment on a person’s behavior, but it does strongly contend that through self-reflective and self-regulatory processes the individual is able to influence his own actions and the environment. The third assumption that frames social cognitive theory is that it is possible for learning to take place without immediate evidence that changes have taken place with a person’s behavior (Bandura, 1977; 1986). Social cognitive theory assumes that such an outcome is possible because learning is not only inclusive of the expression of new behaviors, but learning entails the acquisition of new knowledge, cognitive skills and resources, rules, and values (Bandura, 1977, 1986).

A second theory that informs my dissertation research is Murrell’s (2009) Situated-Mediated Identity Theory. While scholars have formulated numerous identity theories, situated-mediated theory is one of the only philosophies that hones in on the construction of the academic identity of African American students (McClain, 2014; Murrell, 2009).
According to situated-mediated identity theory, the development of self-efficacy, intellectual agency, and emotional resilience is shaped and mediated by the procurement of cultural practices (Murrell, 2009). With regards to students, this theory asserts that the school context is the primary source of the vast majority of their learned and socialized cultural practices (Murrell, 2009). Furthermore, Murrell (2009) proposes that race and racism heavily influence the development of African American students’ academic potential, as these factors attenuate the developmental uprightness of the social and cultural contexts of educational institutions. Therefore, situated-mediated theory recognizes that the developmental task of integrating an “ego-identity” is more complex for African American students in comparison to their White or Asian counterpart, because of the subjection to racialized experiences and negative stereotypes (Murrell, 2009).

A host of social stressors make it difficult for African Americans to find meaning and form their identity. According to situated-mediated theory, African American students’ positionality or oppositionality must be factored into their academic identity development (Murrell, 2009); therefore, we must always take into consideration the images, meanings, and negative ascriptions that African American students seek to “oppose” in their educational experiences. Descriptively, a person’s positionality is a situationally determined social identity, in that, it is the future social self a person seeks to manifest and maintain (Murrell, 2009). It is the way in which African Americans stabilize their social identity in the particulars of a given situation or frame (Murrell, 2009). In summary, Murrell’s framework
emphasizes that the academic achievement of African American students is the product of a dynamic interchange between the development of their racial identity and academic identity.

The third theory that guides my study is the Multidimensional Model of Racial Identity (MMRI) [Sellers, Smith, Shelton, Rowley, & Chavous, 1998]. Uniquely, the MMRI theorizes Black racial identity as a multidimensional construct that is situationally influenced. This model fits very nicely with Murrell’s situated-mediated identity theory, as both that acknowledge identity is situated within the context of one’s environment and mediated by the environment in which they carryout specific roles. Additionally, both theories suggests that identity is not static, but very fluid and situationally-manifested (Murrell, 2009; Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Furthermore, MMRI recognizes that individuals have multiple identities, which are organized within a hierarchical infrastructure (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Significantly, this Black racial identity theory places greater emphasis on an individual’s racial identity status than its development over a period of time (Sellers, Smith, Shelton, Rowley, & Chavous, 1998).

The MMRI has been operationalized in the form of the Multidimensional Inventory of Black Identity (MIBI) [Sellers, Smith, Shelton, Rowley, & Chavous, 1998]. The MIBI consists of seven subscales that provide insight into African Americans’ perceptions of the significance of race and how being African American contributes to their ability to be successful in a science-related field. Moreover, the MIBI was developed to assess how
African Americans perceive others view members of their racial group and how this may impact their own perception of self within that racial group. While the MIBI is comprised of seven subscales (i.e. Centrality, Private Regard, Public Regard, Assimilation, Humanist, Nationalist, and Oppressed Minority), I have decided to not use the instrument in its entirety based on my research questions and previous findings. Therefore, my design will utilize the following subscales: Centrality, Public Regard, Assimilation, and Nationalist. Centrality provides an understanding of how being African American is at the core of who I am, as well as how it is connected to each of my actions.

Centrality reveals that being Black/African American is an important part of my total makeup. This factor is important to my study because it sheds light on how African American students perceive being African American is connected to who they are as a scientist, as well as their overall ability to perform in science. Public regard indicates how African Americans internalize feelings about being African American, as well as how they perceive others view Black/African American people. Ultimately, this aspect influences how African Americans tend to view themselves. I have selected the public regard subscale for this study due to the prevailing messages dominant culture have perpetuated about the science and mathematics abilities of African Americans. Therefore, this measure provides an understanding of how this aspect of racial identity impacts how African American students perceive themselves as “science people”, as well as how it impacts their confidence in their ability to complete science-related tasks. The Assimilationist and Nationalist subscales focus on racial ideology,
and have been chosen based on previous findings indicating that Nationalist ideologies were higher than Assimilationist for students at HBCUs (Sellers, et al, 1997; Cokely & Helm, 2001). Moreover, previous studies found scores for the Nationalist attitude to be higher for African American students who attend HBCUs compared to those attending PWIs, whereas the Assimilationist attitude is higher for those who attend PWIs. Integrating these subscales into my study is important, because they provide insight into how these ideologies impact how African American students position themselves in a domain that is highly concentrated with White males. Overall, the MIBI subscales will provide a deeper understanding into the extent to which racial identity influences science identity and science self-efficacy beliefs of African American science students who attend HBCUs.

Subjectivity Statement

I am an African American female scientist, who grew up in a single parent, low-income home. My mother taught my brother and I the value of working hard, and trusting in the Lord. My personal knowledge and high value for hard work came from watching my mother work several jobs to make sure our basic needs were met. Through observing my mother, I learned that we have limiting factors around us that have the potential to keep us from succeeding. Moreover, they have the potential to shape how we view ourselves, as well as the world around us. In many instances, it did not matter how hard my mother worked, she was never given the same opportunities or privileges as her White counterparts or even Black males. She experienced issues with advancement as a result of the intersection between her
race and her gender. Even though she experienced numerous career related challenges, she always externalized her high motivation, grit, and self-efficacy within the context of her work environments. This helped me to realize that we have intrinsic characteristics and qualities that have the potential to minimize the effects of external barriers or limitations.

As a child, I always said that I was going to be a medical doctor and my family supported this aspiration. I’ve always performed well in school, especially in math and science. I simply love learning, and view myself as a life-long learner. Many of my teachers stimulated my math and science self-efficacy through providing meaningful learning experiences and speaking words of affirmation. I was consistently placed in advanced courses, which meant the majority of my classmates were White. I always wondered why there were very few African American students in my classes. The only advanced math and science learning experiences I engaged in that included a high representation of African American students was an enrichment program that was specifically designed to prepare underserved/underrepresented students in middle and high school for careers in education, science technology, engineering and mathematics.

While the socioeconomic statuses of the students varied, the common denominator was our ethnoracial group. Additionally, all of the instructors were African American. This program promoted a sense of community that I did not feel within my traditional school settings and provided authentic learning experiences that developed my critical thinking skills. The program was held each summer and every Saturday on the campus of a well-
known southeastern Historically Black College and University (HBCU). I participated in the program throughout my middle and high school years, and I believe it augmented the knowledge I developed about success through observing my mother. As I reflect on my experiences in this program, I can see how it ingrained in each participant the notion that race does not dictate whether or not a person can learn and “do” science. If a person is placed in the right learning environment and taught effective learning strategies, then they will experience some degree of success in science.

After graduating high school, I attended a well-known Predominantly White Institution (PWI) where I obtained my Bachelor of Science degree in biology. At the start of my freshman year, a good percentage of my African American peers were biology majors. However, after the first semester about fifty-percent of them transferred into another major. It seemed as if every semester the number became less and less. By my senior year, only a handful of those who started as biology majors persisted and graduated. The environment within the classroom, did not promote a sense of community or self-efficacy. It seemed that the classroom and university culture perpetuate dominant ideologies and the stereotype that African Americans have science and math deficits that are nonexistent in our White counterparts. As a result, for a period of time I adopted these perspectives and questioned my ability to perform in a science context at the same level as White individuals.

After receiving my undergraduate degree, I worked for a few years before entering into a graduate level biology program. This break in schooling, challenged me to seek more
clarity of my purpose. The learning experiences within my masters program were dramatically different from my undergraduate experiences. I received my Master’s in Science from the same HBCU that hosted the enrichment program that I participated in as a teenager. I decided to attend this HBCU because it is in my hometown, and it was to serve as a bridge into medical school. While in this program, I experienced a sense of community that was lacking at the PWI. My undergraduate institution painted a distorted picture of the teacher-student relationship, as well as conveyed a one-sided message of science achievement. This HBCU was a setting that did not necessarily promote competition but collaboration. There was a degree of culturally relevant pedagogy that the instructors practiced on a daily basis, and they made meaningful connections with their students. While several of my peers struggled with the demands of the program, they persisted and graduated. I believe the differentiating factor between African American persistence in science at the PWI and the HBCU is the teacher-student relationship.

I always wanted to be a doctor, and clearly remember saying as an undergraduate that “I would never teach”. This proclamation of never becoming a teacher was definitely not prophetic, as I became a high school biology teacher after earning my masters in biology. My first teaching appointment was at a predominantly Black high school in a low-income area. This school lacked resources and had received negative attention from the media. Prior to my arrival at the school, the students in my first cohort had been taught by a substitute teacher and were very disinterested in biology. Therefore, they displayed negative behaviors and
performed poorly on various benchmark tests. I knew the potential impact relationship could have on the performance of African American students from my own experiences; therefore, in addition to building their knowledge I sought to build relationships. Throughout my tenure at that school, I realized that teaching African American students how to learn science concepts within the context of a relational environment promoted success. It was not that they could not understand or “do” science before having a class with me, it was that these factors were lacking in their earlier experiences. It was through teaching high school that I realized my purpose is to teach and increase the science success of African American students.

I left the teaching scene to work as a product developer for a company that develops educational science products; however, my experiences in the corporate setting gave me insight into another dimension of my purpose. When I looked around the company, and at various science conferences, it became more evident to me that the number of African Americans in science is extremely low. I experienced subtle forms of racism on a daily basis, which has influenced the lens by which I view the experiences of African Americans in science. I tend to view the world using a critical lens, specifically critical race theory (CRT). My experiences with this company helped me to realize that part of my purpose is to explore on a more critical level how racialized experiences impact the science performance of African Americans. My own race, gender and cultural experiences have strengthened my CRT theoretical framework and positioned race and racism at the forefront of my research.
I realize that who I am as a person, greatly influences who I am as both a teacher and researcher. My race, gender, and spirituality interact and influence my construction of knowledge, pedagogies, and research methodologies. My past experiences and my identity shape my research ideas and determine the target populations for my research. Since who I am as a person greatly influences the decisions I make as a researcher, I have intentionally confronted my biases and personal assumptions. This has allowed my research to be more objective, and eliminate the likelihood of manipulated data so that it is aligned with my biases. At this point, I possess a greater awareness of how my personal, cultural, and historical experiences have shaped my approach to research as a whole.

My knowledge of the subjects in my study is an area of bias. The target population of the participants in my study is African American science majors. Many of the students who participated in this study were students who attend the HBCU that I attended for my master’s work. Additionally, I have worked for this HBCU for seven years as a biology instructor and advisor. Therefore, I have interacted with many of the students who participated in this study both inside and outside of the classroom. I realize that my view of the school and how it fosters the development of the psychological constructs of interest through positive teacher-student interactions has some biases. Thus, it was vital for me to put any biases that may have developed about this student demographic and the university aside during interviews and data analysis.
My personal experiences, as both a science student and a science educator, have served as the launching pad for the proposed research. While my subjectivity statement has given insight into how my personal experiences influence my dissertation research, it does not provide the specific details of my research focus. In the section dedicated to my purpose statement, I will provide a succinct overview of my dissertation study.

**Purpose Statement**

This section of the study highlights the original intentions of my study, as well as why my study is relevant:

**Statement of the Problem.** Science, technology, engineering, and mathematics (STEM) careers provide great financial stability and are expected to experience a boom within the job market; however, very few African Americans are entering into or persisting through these fields to experience these advantages. Today, the majority of African American college students are enrolled in predominantly White institutions (PWIs) (Fries-Britt & Turner, 2001); however, historically Black colleges and universities (HBCUs) produce a disproportionately high number of minority graduates in science, technology, engineering, and mathematics (STEM) (Shorette & Palmer, 2015). The disparity between the number of African American STEM graduates from HBCUs and PWIs is a sign that there is a problem at the institutional level as it relates to educating African American students in science. Moreover, the disparity also alludes to need to gain a deeper understanding of the environment created by HBCUs that has resulted in a high volume of STEM graduates, as
this understanding may help to resolve the low number of African American STEM graduates from PWIs. While many programmatic initiatives and interventions have been developed to address the underperformance and underrepresentation of African Americans in science, we have not really seen considerable improvements. Individually, studies have reported that science identity, science self-efficacy beliefs, racial identity, and university context influence the science achievement of African American students; however, rarely have researchers explored how the interconnections between these constructs influence achievement.

Goals of the Research. The purpose of this research study is four-fold. The first goal was to gain a deeper understanding the relationships between science identity, racial identity, and science self-efficacy beliefs of African American students attending HBCUs. The second goal was to explore the extent to which these constructs influence the science achievement of African American students attending HBCUs. Third, the study sought to investigate the degree to which the pre-college experiences of African American students attending HBCUs influence science identity, racial identity, and science self-efficacy beliefs, and college science achievement. My final research goal was to gain a more detailed understanding of the ways the African American students’ perspectives of their experiences at HBCUs influence their science self-efficacy beliefs, science identity, and racial identity.

Mixed Method Rationale. In order to conduct this study I will employed a concurrent mixed methods design to explore my research hypotheses and questions.
Ultimately, this methodology allowed me to test a theoretical model about the relationships between the three aforementioned constructs, and modify it by converging numeric trends from precise, instrument-based measurements with specific contextual details from the narratives of participants. Thus, the utilization of both quantitative and qualitative data enriched my understanding in ways that typically does not occur through a single form of data.

**Significance**

This dissertation study has the potential to make very useful contributions to the fields of educational psychology and science education. First, there is almost a nonexistent body of research that explores the relationships between science identity, racial identity, and science self-efficacy of African American students. More specifically, the science identity and science self-efficacy of African American students have not been evaluated through the lens of critical race theory. For this reason, the findings of this study will provide a more authentic account of the development and integration of their science identity and science self-efficacy beliefs.

Second, investigations into the psychological constructs have not been frequently conducted with students attending HBCUs, which is where the vast majority of African American scientists receive their undergraduate degrees; therefore, the discovery of links between the constructs of interest will be very meaningful. Such findings will help to inform the development of strategies that college professors at HBCUs may use to promote the
development of the science identity, racial identity, and science self-efficacy beliefs of
African American students. Third, this study will shed light on the experiences provided by
HBCUs that foster the development of the psychological factors of interests, which may
potentially serve as a template to be replicated by faculty members at predominantly White
institutions (PWIs). This is particularly significant as the use of such empirically grounded
models or strategies may potentially establish new science cultural norms that are more
inclusive of and welcoming to African Americans; thereby, minimizing the property right of
White individuals to determine

Fourth, while many universities and government agencies have developed programs
and interventions to address the needs to African American college students in science, there
is a need to base their development upon empirical findings; therefore, discovering constructs
that influence how students identify as scientists will lend to the development of more
targeted interventions and programs. Last, many of the research studies that have investigated
these psychological constructs or their relationships with one another have been performed in
a qualitative fashion (Britner & Pajares, 2006; Britner et al., 2012; Carlone & Johnson, 2007;
Ceglie, 2011; Gee, 2001), thus this mixed method approach will make a very significant
methodological contribution.

**Operationalization of Terms:**

*Racial Identity* - the process of becoming Black, otherwise known as Nigrescence (Cross,
1971, 1991); the extent to which one’s Blackness is the core to his/her sense of self (Sellers
et al., 1997).

Centrality - the normative significance of a person’s race in the individual’s self-concept (Sellers et al, 1997).

Public Regard - the extent to which a person feels others view African Americans positively or negatively (Sellers et al, 1997).

Assimilationist - an ideology adopted by an individual that emphasizes the similarities between African Americans and mainstream society (Sellers et al, 1997).

Nationalist - an ideology adopted by an individual that emphasizes the uniqueness and importance of being of African descent (Sellers et al, 1997).

Racial Salience - the significance of a person’s race in his/her self-concept at a specific moment in time (Sellers et al, 1997).

Science Identity - the sense of who individuals are, what they believe they are capable of, and what they want to do and become in regard to science (Brickhouse, 2001).

Science Self-Efficacy Beliefs - one’s appraisal of his/her ability to perform and/or complete science related tasks

**Overview and Organization of Dissertation**

This dissertation consists of five chapters. Chapter 1 provides an overview of the problem, purpose, and rationale for this study. It provides a backdrop that informed this study, discussed the goals of the study, introduced the theoretical framework, and highlighted my personal subjectivities connected to this study. Additionally, chapter 1 provides a
rationale for employing a mixed methods approach, and the significance of the study. Chapter 2 is a comprehensive review of the literature and research related to science identity, racial identity, science self-efficacy, and Historically Black Colleges and Universities. Moreover, the chapter gives an overview of Critical Race Theory, which is the analytical lens of this dissertation work. Chapter 3 provides the methodology, research questions and hypotheses, description of the participants, and overview of data integration. Chapter 4 presents the quantitative and qualitative findings through a weaving approach to data integration. Chapter 5 summarizes and evaluates the research, including implications and recommendations. Additionally, the chapter provides limitations and future directions.
CHAPTER II: LITERATURE REVIEW

The overarching goal of this study is to investigate the relationships between racial identity, science identity, and science self-efficacy beliefs of African American students within the historically Black college and university context. Before I explain the overall design of my study, it is critical for me situate my research problem within the theoretical framework. This process will be initiated by an examination of relevant literature. Specifically, I will discuss literature on identity development, placing a strong emphasis on racial and science identity development. Afterwards, I will discuss the literature on self-efficacy, focusing heavily on the malleable nature of self-efficacy beliefs. Then I will discuss HBCUs, providing an emphasis on the nature of the institutional environment and how these institutions promote the academic achievement and self-development of African American students. I will conclude my review with a discussion of Critical Race Theory, and its use as an analytic and theoretical tool to evaluate the relationships between racial identity, science identity, and science self-efficacy beliefs.

Identity Theories and Identity Development

College students face a major stage of development that provokes them to develop their own identity (Fleming, 1984; Komarraju & Dial, 2014). The discourse and research on identity has increased over the years, causing it to become one of the most salient and commonly researched constructs in the social sciences (Brubaker & Cooper). According to Brickhouse (2001), identity “accounts for the importance of both individual agency as well as
the societal structures that constrain individual possibilities” (p. 286). Scholars have yet to settle on a clear explanation of identity due to its great heterogeneity. There have been debates over whether identity is stable or fluid, singular or plural, and if it is personally constructed or socially constructed. Gee (2001) asserts that all individuals have multiple identities that are connected to their performances in society rather than to their “internal states”. Stets and Burke (2014) clearly defines identity as “a set of meanings that defines individuals in terms of the roles they occupy, the social categories or groups they belong to, and the individual characteristics that define them as unique persons” (p. 412). Kroger (2001) places emphasis on identity’s ability to help one to navigate life paths and decisions, while Gee (2001) states that identity is being recognized as a certain “kind of person” in a given context.

The infusion of identity into the social sciences and public discourse within the United States dates back to the 1960s, with the most notable contributions stemming from the work of Erik Erikson (Brubaker & Cooper, 2000). Erikson’s work on identity formation focused on the healthy development of an enduring ego identity, a construct that was extrapolated from Freud’s psychoanalytic model of the human psyche (Erikson, 1950). He postulated that identity development occurs across the lifespan, and is usually insentient to both the individual and society (Erikson, 1956). According to Erikson, emerging adulthood is marked as the stage in an individual’s life cycle in which the most critical process of identity development occurs (1956). More specifically, it marks the point where individuals must
establish their identity in order that move from childhood to adulthood. This is essential information, as the participants of this study fall within the age range that has been identified as emerging adulthood.

Identity may reference self-definitions of individuals or their group associations. For this reason, present approaches to identity give attention to one or more of the three categories for which we define identity: individual, relational, and collective (Schwartz, Luyckz, & Vignoles, 2011). Individual or personal identity refers to the level of the individual person (Schwartz, Luyckz, & Vignoles, 2011), which includes the cluster of meanings that are connected to and sustain the self as an individual (Stets & Burke, 2000). The meanings ascribed to self, function across different roles and conditions (Stets & Burke, 2000). Individual identity may involve goals, values, beliefs, decision-making standards, and self-esteem and self-evaluation. Relational identity refers to an individual’s roles with regard to other people, such as daughter, student, mother, etc. (Schwartz, Luyckz, & Vignoles, 2011). Collective identity describes an individual’s identification with the different groups and social categories to which he belongs, the meanings they ascribe to these social categories and groups, and the feelings, beliefs, and mindsets that result from their identification with them (Schwartz, Luyckz, & Vignoles, 2011). Collective identity denotes “sameness” amongst the members of a group (Brubaker & Cooper, 2000). The present study will give attention to all three of the aforementioned identity categories of the participants, as this approach will provide a deeper understanding of the relationship between their racial
Social Identity Theory and Identity Theory. There are two theoretical conceptions of identity that this review will give attention to: social identity theory and identity theory. There are several similarities and intersections between these two theories that may possibly allow for their unification; yet, there are distinct differences that serve as barriers to such a merger. Stets and Burke (2000) postulated that conflating the two theories would possibly establish a more integrated view of the self. Both theories speak to the social nature of self as constructed by societal influences, and disregard the notion of self as being autonomous (Hogg, Terry, & White, 1995). In the two theories, there is a reflexive nature to self; therefore, self has the ability to categorize or name itself in certain ways in regards to other social categories (Stets & Burke, 2000). In social identity theory, this process is referred to as self-categorization; conversely, it is known as identification in identity theory (Stets & Burke, 2000; Hogg, Terry, & White, 1995). It is through the process of categorization or identification that an identity is created.

Within identity theory, identity/self is linked to a specific role (Stets & Burke, 2000), and the meanings individuals assign to themselves while operating in that role (Stets & Burke, 2014). The link that connects identities, perceptions, and behaviors is meaning (Burke & Reitzes, 1981). Once an individual occupies a role, the expectations and meaning associated with that role generate a set of standards that tend to guide his or her actions (Burke & Reitzes, 1981). Taking on a specific role entails performing to meet the
expectations of the role, interacting with role partners, and manipulating the environment to control the resources needed to sustain identity and interactions (Stets & Burke, 2000). It is not that identities are reliable predictors of behavior, but they are good predictors of the meanings that are expressed through the behaviors (Stets & Burke, 2014). Burke and Reitzes (1981) contended that there must be congruence between the meanings ascribed to occupying a role with those given to the behaviors that the person enacts in the role. Thus, they hypothesized that changes in role performance may be predicted from changes in role/identities. Burke & Reitzes (1981) investigated the college student/role to ultimately discern the link between identity and role performance, and found that the strength of the relationship between identity and performance increases when their meanings are congruent.

In accordance with identity theory, Burke & Stets (2009) constructed a model of identity that consists of four components: input, identity standards, a comparator, and an output. All of the components work together to help maintain perceived meanings in a specific range, similar to the workings of a thermostat. Thus, as an identity is activated in a given situation, the different meanings that define the identity serve as a standard for people and a feedback loop is triggered. Every identity has meanings that characterize the identity. The set of meanings are known as the identity standard. Perceptions are at the nucleus of identity processes, as it is essentially our own perceptions that we are attempting to regulate. Once an identity is activated, a person starts to monitor the kinds of meanings that are being displayed through his/her performance, as well as how he/she perceives others see him/her in
the situation. These interpretations made by the person form the input. The appraisals made by the person are constantly loaded into the comparator, where they are compared to the identity standards; therefore, inducing a process of self-verification. The comparator determines the difference between the two, and generates an “error signal” when the two do not match. When the two are equivalent it is known as identity verification, while a mismatch is known as identity non-verification. The final component is the output into the situation. Specifically, the output is the behavior enacted in the situation, and it is contingent upon the signal transmitted by the comparator.

According to social identity theory, a social identity is derived from a person’s group memberships (Brown, 2000). At the core of social identity theory is the idea that in social situations people view themselves and others as group members, instead of as separate individuals (Ellemers & Haslam, 2012). Stets and Burke (2000) describes a social groups as a cluster of people who view themselves as member of the same social category. Individuals are categorized into the same group under the assumption that they all share a group-defining feature that separates them from individuals who lack this feature (Ellemers & Haslam, 2012). It is through a process of making social comparisons between an in-group (i.e. persons who share similarities with self) and relevant out-groups (i.e. persons who differ from self) that a positive identity emerges (Brown, 2000). A central aspect to this process of categorization is coming to the realization that “self” may be included in some categories and excluded from others (Ellemers & Haslam, 2012). Being a member with a specific group
means being like other individuals within the group, and viewing things from the group’s perspective (Stets & Burke, 2000). Thus, social identity theory may be viewed as a social psychological theory that seeks to explicate group processes and intergroup relations (Hogg, Terry, & White, 1995), and gives more attention to the social context as the primary determinant of self-definition and behavior (Ellemers & Haslam, 2012).

A concept that connects social identity theory with identity theory is identity salience. Identity salience is the possibility that identity will be activated in a particular situation or enhance the influence of one’s group membership on perception and behavior (Hogg, Terry, & White, 1995; Stets & Burke, 2000; Stryker, 1968). Consistent with identity theory, the different roles of an individual may be arranged in a hierarchical manner with regard to the likelihood that they will be enacted. This leads to the notion of salience hierarchy, which ranks the roles a person may enact in a situation when there is more than one suitable role (Stryker, 1968). Thus, the higher an identity’s rank in the hierarchical scheme, the more closely linked it is to a given behavior. Stryker (1968) hypothesized that the higher an identity is positioned in the salience hierarchy, the greater the chances of congruence between role performance and the expectations linked to the identity. Additionally, he hypothesized that individuals will search for opportunities to enact very salient identities (Stryker, 1968). With regards to African Americans, navigating and negotiating salient identities is very complex, as they are faced with the challenge of potentially negotiating identities from three different social realms.
Triple Quandary Theory. In an effort to determine why such a large achievement gap exists between White and African American students, researchers have investigated identity formation and achievement for African American students (Murrell, 2009). The literature on such investigations show that the developmental task of creating an integrated ego-identity is more complex and cumbersome for African Americans (Boykin, 1986; Murrell, 2009). For African American students the process of finding meaning and identity formation involves a number of external stressors and pressures that may not be experienced by other social groups. Boykin (1986) provides an appropriate example of this through his *Triple Quandary Theory*. He asserts that if we are to gain a rich understanding of the African American experience, we must view it in light of an interplay among three realms of experiential negotiation: the mainstream experience, the minority experience, and the Black cultural experience.

Essentially, these are three social identities African Americans must negotiate. The mainstream realm is the most ubiquitous and is a part of every person’s experience. Blacks participate in a host of systems, and share values that are broadcasted by general American institutions and by mass media; however, their participation is moderated by simultaneous negotiation that is occurring through the minority and Black cultural realms. Moreover, their participation is also tempered by the hegemony of White American values that permeate all dimensions of mainstream culture. The minority experience is centered on exposure to social, economic, and political oppression. The oppression for African American is directly
connected to race; however, other groups have minority status but it is not linked to their race (Boykin, 1986). Last, African Americans participate in a Black cultural experience that is grounded in a traditional African spirit.

The triple quandary for African Americans is birthed out of conflicts by the three aforementioned realms of negotiation. This phenomena is clarified by Boykin (1986),

They are incompletely socialized to the Euro-American cultural system; they are victimized by racial and economical oppression; they participate in a culture that is sharply at odds with mainstream ideology. (p. 66)

African Americans experience a triple burden because they have to make attempts to integrate three divergent identities simultaneously: mainstream, minority, and Black cultural (Boykin, 1986). Thus, any conceptual model that focuses on the identity development of African Americans should take into consideration the stringent negotiation demands that are experienced during the developmental process.

Individuals have multiple identities that are connected to their societal performances (Boykin, 1986; Cornell & Hartman, 2007; Gee, 2001; McClain, 2014; Murrell, 2009). In light of this information, the next two sections will give attention to racial identity and science identity, while taking into consideration the negotiation process experienced by African American students during identity development. The information on identity theory and social identity theory provided in this section of the literature review will prove to be
critical to understanding the notion of Black racial identity.

**Racial Identity.** African American students transition through various stages of Black racial identity (BRI) development, which DeCuir-Gunby (2009) describes as “the attitudes and beliefs that an African American has about his or her belonging to the Black race individually, the Black race collectively, and their perceptions of other racial groups” (p. 103). With regards to the psychological experiences of African Americans, racial identity has been one of the most commonly researched areas (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Since the onset of racial identity theories, researchers have struggled with understanding the significance and meaning of race (Cross, 1991; Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Every member of society deals with the struggles of identity development; however, minorities also have to address this matter within the context of race (Scottham, Cooke, Sellers, & Ford, 2010). In the case of African Americans this warrants responding to the question of “What does it mean to me to be African American?” (Scottham, Cooke, Sellers, & Ford, 2010, p. 21). Ultimately, the manner in which African Americans find an answer to this question determines their racial identity.

Historically, there have been two lines of thinking applied to theorists’ development of racial identity models: process or content (Scottham, Cooke, Sellers, & Ford, 2010). With regards to process, theorists focus on the manner in which an individual’s attitudes regarding race develop and transform across the lifespan; therefore, this approach is categorized as being developmental (Scottham, Cooke, Sellers, & Ford, 2010). A salient point across the
literature is that racial identity development is not a single process, but a combination of experiences and changes that take place at different points in one’s life. The latter places emphasis on the content of a person’s attitudes toward this racial membership (Scottham, Cooke, Sellers, & Ford, 2010). The research design for my study is more aligned with the content paradigm, in that I will focus on the content of the students’ race-related attitudes and beliefs.

The early theories exploring the nature of Black identity development gave considerable attention to aspects of group identity, while overlooking the role culture plays in the developmental process (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Between the 1930s and 1970s, the ideas regarding Black identity development were oversimplified to self-hatred (Cross, 1994), which stemmed from the identity preferences of Black nursery school children participating in a “Doll Test” (Clark & Clark, 1947). The Clark team (1947) reported that when the Negro children were given dolls that ranged in skin color and asked which one is the prettiest and nicest, the vast majority of the children chose the White doll over the colored dolls. Their findings led researchers to conclude that Black children were socialized in a way that led them to reject their Blackness while identifying more closely with Whiteness. Researchers exploring this phenomenon in the late 1960s shifted the focus of research to the “uniqueness of their oppression and cultural experiences” (Sellers, Smith, Shelton, Rowley, & Chavous, 1998, p. 19).

Detailed linear and standard models have been constructed to elucidate and predict
racial self-discovery and development. However, the complexity of race as a social construct has made reducing the construct into a theory, let alone a model a very daunting task. While there are numerous racial identity models and scales that have been developed by scholars over the years, my literature review will only highlight two of the most widely researched and used models.

**William Cross and nigrescence theory.** The earlier conceptions of Black identity development were invoked by and modeled after general identity development theories. Specifically, William Cross and other theorists assumed that nigrescence, which is “the process of becoming Black” (Cross, 1994, p. 120), entailed all-inclusive personality and identity changes (Cross, 1991). Cross (1991) expressed that these earlier models depicted a comprehensive change because the trends in “mainstream” research or dominant ideologies pointed in a comprehensive direction. These initial racial identity development models were based on clinical observations, case studies, and participant observations (Cross, 1991). With that said, Cross developed one of the most influential seminal Nigrescence models based on his own self-analysis (Cross, 1991). In devising a model, he hoped to elucidate the potency of racism and help Blacks move toward complete freedom. Cross (1995) explains:

Nigrescence Models attempt to capture the stages that African Americans traverse when experiencing a major shift in the racial self-identification. In addition, to a description of the key dynamics associated with each stage… (p.119)
Cross’ Black racial identity development models have been frequently utilized and validated in a number of empirical studies (Anglin & Wade, 2007; Davis, Aronson, & Salinas, 2006; Worrell, Vandiver, Schaefer, Cross, & Fhagen-Smith, 2006).

Cross’ original model was grounded in his belief that Black identity development occurs during late adolescence/emerging adulthood, and focused on the identity development of Blacks in American; however, his model was criticized for being too simple (Cross, 1978; Parham, 1989). Cross’ (1978, 1991, 1994) first model includes five stages: Pre-encounter, Encounter, Immersion/Emersion, Internalization, and Internalization-Commitment; however, it was later reconceptualized to depict a recycling through the stages instead of a linear transition. The model depicts development in which a Black person transitions from a negative to more positive racial identity (Cross, 1978; Cross, 1991; Cross, 1994; Cross, 2012). Such an arrangement makes it seem as if an individual is striving to achieve the highest level and once it is reached, identity development ceases. While the model is able to capture the stage/identity attitude of the individual in a quantitative manner, it does not account for the lived experiences that catalyze the transitions from one stage to another.

Even though Cross saw the need to revise his original model in 1991, his original 1971 model continues to be cited and used for empirical studies (Vandiver, Cross, Worrell, & Fhagen-Smith, 2002). Cross’ (1991) nigrescence model was later extended by Thomas Parham, such that is covered the entire life span. The primary reason for researchers continuing to use the original model was due to its association with the Racial Identity
Attitudes Scale (RIAS), which was developed by Parham and Helms (Vandiver, Cross, Worrell, & Fhagen-Smith, 2002). The development of the RIAS lead to an upsweep in racial identity development research (Worrell, Vandiver, Schaefer, Cross, & Fhagen-Smith, 2006). Subsequently, the Cross Racial Identity Scale (CRIS) was designed to measure the theoretical constructs presented in Cross’ most recent model (Vandiver, Cross, Worrell, & Fhagen-Smith, 2002) and has been used in a variety of Black racial identity studies (Anglin & Wade, 2007; Worrell, Vandiver, Schaefer, Cross, & Fhagen-Smith, 2006; Worrell, Mendoza-Denton, Telesford, & Simmons, 2011)

**Multidimensional model of racial identity.** The *Multidimensional Model of Racial Identity* was developed by Sellers, Smith, Shelton, Rowley, & Chavous (1998) with the goal of gaining a deeper understanding of the self-concepts of African Americans and the meanings they place on being members of that particular racial category. Sellers, Smith, Shelton, Rowley, & Chavous (1998) assert that the MMRI “represents an amalgamation of a number of existing theories on group identity that is sensitive to the historical and cultural experiences that make racial identity a unique form of group identity for African Americans” (p. 21). The MMRI closely resembles Cross’ model in a variety of ways. In fact, the scales that operationalize these theoretical models contain several subscales that are similar, including Assimilation, Afrocentricity (paralleling Nationalism, and Multiculturalist Inclusive (paralleling Humanist). The MMRI is a multidimensional model that is centered on three stable dimension: *racial centrality, racial regard, and racial ideology* (Sellers, Smith,
Shelton, Rowley, & Chavous, 1998). Specifically, racial salience and centrality reference the weight that individuals connect to race when defining themselves, while racial regard and ideology refer to the meaning an individual gives to being Black (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Significantly, a person’s racial salience is determined by both the context and his inclination to define himself in terms of race (Sellers, Smith, Shelton, Rowley, & Chavous, 1998).

The MMRI model assumes that (1) identity is both situationally influenced and a stable component of the individual, (2) individuals have multiple identities that are arranged in a hierarchy and (3) the person’s perception of their racial identity is the very best indicator of his identity. The quality of “self” being both situationally influenced and stable mimic the ideologies of most identity theorists, who postulate that “self” possesses both of these characteristics (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Ironically, Sellers and colleagues (1998) assert that the racial identity of African Americans possesses dynamic components that are completely vulnerable to contextual clues and allow the stable properties of one’s identity to impact behavior at the level of a specific event. Additionally, there are some properties within racial identity that are immutable.

With regards Sellers et al. (1998) to the second assumption, it is very much aligned with identity theory’s notion of salience hierarchy that contends that the most salient identity is the one that will cause a person to enact a given behavior within certain contexts. Distinctively, the second assumption of the MMRI accounts for an individual’s multiple
identities, which is not accounted for in Cross’ nigrescence model. To this end, I considered the MMRI to be an appropriate quantitative tool for my study because my goal was to learn more about the interactions between an African American student’s racial identity and science identity. As for Sellers et al. (1998) third assumption, it acknowledges the role of society in molding a person’s identity, but places greater emphasis on the individual’s construction of his identity (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Therefore, the MMRI hones in on the person’s self-perceptions. My guiding assumption was that the MMRI would be an excellent tool to use to detect correlations between an African American student’s racial identity and science self-efficacy since both attempts to capture an individual’s self-conceptualizations.

The MMRI was operationalized in the form of the Multidimensional Inventory of Black Identity (MIBI) (Scottham, Cooke, Sellers, & Ford, 2010; Sellers, Smith, Shelton, Rowley, & Chavous, 1998). This scale consists of three scales: centrality, ideology, and regard. The centrality scale measures the degree to which race is important to the person. There are 4-item ideology subscales that make up the MIBI: Humanist, Assimilationist, Oppressed minority, and Nationalist. Last, the MIBI consists of two Regard subscale: public regard and private regard. This scale has been used to determine relationships between racial identity and affective patterns (Jones, Lee, Gaskin, & Neblett, 2014); psychological functioning (Sellers, Copeland-Linder, Martin, & Lewis, 2006); and personal self-esteem (Rowley, Sellers, Chavous, & Smith, 1998).
While there are numerous Black racial identity theories, this brief review of the BRI literature elucidates why the multidimensional model of racial identity is appropriate for exploring my research questions. With regards to general identity theories, the MMRI takes into consideration the notion that identity is comprised of multiple dimensions; therefore, the model allowed for a thorough investigation into the relationship between various dimensions of racial identity and science identity. According to Murrell’s situated-mediated identity theory, the racial identity of African American students is innately connected to their academic identity. Thus, the next section will provide an overview of the literature on science identity in order to lay the foundation for investigations into connections between the multiple aspects of identity development as they relate to race and science achievement.

**Science Identity.** The notion that formation of a healthy science identity is essential to learning is becoming more significant to science educators and researchers (Brickhouse, 2001; Carlone & Johnson, 2007). Science identity is who students are, what they are capable of doing, and what they aspire to do and become as it relates to science (Brickhouse, 2001). Students’ science identity is based on their perceptions of themselves and how they perceive others view them as they engage in science-related tasks (Aschbacher, Li, & Roth, 2010). Researchers have reported important relationships between student identity, self-confidence, and science self-efficacy (Aschbacher, Li, & Roth, 2010; Williams & George-Jackson, 2014). Others have shed light on the role of learning environments play in science identities formation (Beier, Miller, & Wang, 2012; Carlone & Johnson, 2007; Fraser, Shane-Simpson,
A number of studies have been conducted to explore science identity at the middle school and high school levels (Brown B., 2004; Aschbacher, Li, & Roth, 2010; Carlone, 2004; Brickhouse, Lowery, & Schultz, 2000), but very few studies have investigated it at the college level (Carlone & Johnson, 2007; Ceglie, 2011; Hazari, Sadler, & Sonnert, 2013; Marlone & Barabino, 2009).

The field of science has a prevailing sociohistorical reputation and is reproduced as an “objective, privileged way of knowing pursued by an intellectual elite” (Carlone, 2004, p. 394). Science is a masculine pursuit whose members have to possess a willingness to embrace hegemonic notions of masculinity in order to achieve success (Carlone, Webb, Archer, & Taylor, 2015). The findings of feminist researchers have shown that scientific knowledge reflects the gender and racial beliefs of society because it is culturally situated (Brickhouse, 2001). The collective science experiences of women of color who participated in Ceglie’s (2011) study conveyed the message that women of color are not a part of science. Carlone and colleagues (2015) proclaim that “the ‘ideal science student’ is a classed, racialized, and gendered construction” (p. 438). Thus, student science identity involves the way individuals see themselves vis-à-vis this culturally grounded and biased science. It is critical to understand students’ identities and how they interact with their science identities because the degree to which students engage in science learning is influenced by how they view themselves and whether or not they are the “kind of person” who does science (Brickhouse, Lowery, & Schultz, 2000).
Carlone and Johnson (2007) view science identity as being tenuous, situationally emergent, and shaped through practice. In seeking to understand students’ performance in science and decisions to pursue STEM careers, many researchers have utilized the concept of identity while framing it within situated-learning (Aschbacher, Li, & Roth, 2010; Brickhouse, Lowery, & Schultz, 2000; Carlone & Johnson, 2007; Carlone, Webb, Archer, & Taylor, 2015). Situated-learning is a model of practice theory that views authentic learning as occurring through daily social interactions within “communities of practice”, inclusive of those occurring in school, home, or community (Lave & Wenger, 1991). Brickhouse, Lowery, & Schultz (2000) stress that students are only able to learn science when they develop identities that are compatible to their scientific identities.

We need to know how students are engaging in science and how this is related to who they think they are (what communities of practice they participate in), e.g. a good student, a basketball player, and who they want to be (what communities of practice they aspire to), e.g. a teacher, a mother, a gemologist, an obstetrician (Brickhouse, Lowery, & Schultz, 2000, p. 443) develop identities that are compatible to their scientific identities.

When taking into consideration the “communities of practice” that students participate in, we must not fail to realize that their involvement in these communities is not static. Individuals may be members of a variety of social communities simultaneously (Brickhouse, 2001), thus having to negotiate their identities in accordance with the rules and values established by these communities (Aschbacher, Li, & Roth, 2010). In response to
learners’ participation in different communities being dynamic, researchers should pay special attention students’ multiple social identities (Brickhouse, Lowery, & Schultz, 2000). It is essential that communities of practice that are relevant to the development of scientific identities be present and accessible to students (Brickhouse, Lowery, & Schultz, 2000).

In seeking to gain a deeper understanding of science identity development, it is beneficial to consider “cultural production” which includes the meanings groups develop during their day-to-day activities that are aligned with or counter-meanings implied by larger social structures (Carlone & Johnson, 2007). By examining cultural productions, we are able to look into the way sociohistorical legacies (i.e. the prevalence of white male scientists) are replicated through local practices and how groups (i.e. African Americans majoring in science) in their daily practices might counter these legacies to produce new meaning (Carlone, 2004; Carlone & Johnson, 2007). Everyday practices in a science classroom or laboratory either reproduce or dismantle global sociohistorical meaning of science (science identities) and scientist (Carlone, 2004). The local meanings (cultural reproductions) emerge from the daily practices.

The concept of “science identity” has recently begun to move to the forefront of science education research (Brickhouse, 2001; Brickhouse & Potter, 2001; Brickhouse, Lowery, & Schultz, 2000; Carlone & Johnson, 2007), yet its complexity has made it very difficult to operationalize or to use as an analytic tool. In response to the lack of conceptual models, Carlone and Johnson (2007) sought to develop a model of science identity based on
their ethnographic study of women of color. Carlone and Johnson followed 15 women of color through their undergraduate and graduate studies as well as into the initial stages of their science-related careers. The participant’s undergraduate matriculation occurred at a predominantly white institution (PWI). Their research goal was to address how women of color meanings of science and of themselves as a science professional transform over time. They constructed a conceptual model of science (see Figure 1) identity prior to the study to inform and to be informed by their data; therefore, the participant’s stories were interpreted through a science identity lens. The initial model captured three aspects of identity: competence, performance, and recognition. The model was informed by Gee’s theory of identity, which delineates identity as the type of person an individual seeks to be and enact in the present.

![Figure 1. Model of science identity (Carlone & Johnson, 2007)](image)

According to Carlone and Johnson (2007), a person cannot enact a science identity without first making visible to (performs for) other individuals his competence in science-related tasks, and others recognizing his performance as trustworthy. Therefore, an individual
with a strong science identity would give him/herself high rating and receive high ratings from others in each of these three categories. They posited that the benchmarks for credibility vary based on context (Carlone & Johnson, 2007). Additionally, the model is aligned with a social constructivist paradigm, thus accounting for the social constructed nature of science identity. Upon a thorough analysis of their findings, the researchers revised their model to highlight the differentiated impacts of recognition. While their models are based on the assumptions that gender, racial, and ethnic identities influence a person’s science identity, it does not provide a detailed representation (see Carlone & Johnson, 2007 to view the models). This dissertation study seeks to add information regarding racial identity to Carlone and Johnson’s existing model.

Marlone & Barabino (2009) expanded Carlone and Johnson’s (2007) understanding of the role that recognition plays in the science identity development process through conducting ethnographic focus groups and interview with 24 females in STEM disciplines. In their expansion of the role of recognition, the two researchers suggested that identity requires a symbolic foundation, which is the feeling that one is considered worthy of participating in an institution. The currency of the institution is knowledge and prestige; with prestige being indicated by the recognition one receives from others within the symbolic field of meanings associated with science practices. An example may be receiving an invitation by faculty to participate in a symposium. Carlone and Johnson (2007) expressed that recognition functions as a mechanism to perpetuate the status quo, as “it is much easier to get recognized as a
scientist if your ways of talking, looking, acting and interacting align with historical and prototypical notions of scientist” (p. 1207). Therefore, faculty are most likely give recognition to students who look, talk, behave, think, and socialize much like themselves. In both studies, female participants functioned in communities of practice that necessitating bidding for recognition, and potentially being overlooked by meaningful others due to their race.

Drawing from the information discussed in this section, the extent to which an African American student engages in science and science-related activities is in part contingent upon the degree to which he sees himself as a “science person”. While individuals may have multiple identities, the science identity research presented in this section highlights that the salience of one’s science identity is influenced by the context in which one learns and applies science knowledge. Of great significance, Carlone and Johnson’s (2007) model presents performance and competence as two key components of science identity. As you will see in the next section, this insight connects very well with one of Bandura’s proposed sources of self-efficacy beliefs. Thereby, providing a foundation upon which I have generated my hypothesis of science identity as a mediator between science self-efficacy beliefs and college science achievement. The coverage of self-efficacy in the next section will provide a clear theoretical definition of self-efficacy, the sources that help to shape one’s self-efficacy beliefs, and highlight investigations into science self-efficacy beliefs.
Self-efficacy and Science Self-efficacy

For several decades, educators and researchers have gained an increased awareness of the critical role students’ self-beliefs play in their motivation to learn and academic achievement. In the 1970s and 80s, researchers began to evaluate self-beliefs in a more task-specific manner, with considerable attention being given to self-efficacy (Zimmerman, 2000). In his seminal work, Albert Bandura (1977a) laid the foundation for much of our understanding regarding the relationship between perceived self-efficacy and behavior. In particular, Bandura’s (1977a) proposed self-efficacy model provided insight into the sources, mediating mechanisms, and varied effects of self-efficacy beliefs. Bandura (1986) defines perceived self-efficacy as “people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances” (p. 391). Hughes, Galbraith, and White (2011) describe self-efficacy beliefs as “meta-judgments, or reflections about one’s mental and physical abilities” (p. 278). Self-efficacy appraisals influence thought patterns that may be either help or hinder the enactment of a behavior required for completing a task (Bandura, 1989).

As a component of Bandura’s (1986) social cognitive theory, self-efficacy is a self-reflective process that involves a generative capability; therefore, it serves as a mediator between knowledge and action (Pajares, 1996). In order for individuals to competently perform a task, they must possess both the relevant skills and self-efficacy beliefs to employ the skills effectively. Perceived self-efficacy does not give as much attention to the skills an
individual may possess as it does to the judgments of what the individual is capable of doing with the skills (Bandura, 1986). Thus, Bandura (1986) proposed that usually the way people behave might be predicted by their beliefs about their capabilities more than by what they are actually capable of accomplishing. This assertion is based off of the premise that beliefs guide what people will do with the knowledge and skills they possess. Bandura (1977a) suggested that one is able to generate present motivation for specific behaviors due to his or her capacity to represent future consequences in thought. Self-efficacy judgments exclusively refer to future functioning and are evaluated before an individual performs a specific task (Zimmerman, 2000). Thus, the antecedent nature of efficacy beliefs positions them as causal contributors to academic motivation (Bandura, 1989; Zimmerman, 1977b, 2000).

According to Bandura’s social learning theory (1977b), individuals are only able to function effectively when they are able to anticipate the consequences of different events and courses of actions and appropriately adjust their behavior. Furthermore, he contended that humans do not simply respond to various stimuli, but interpret whether or not the stimuli have a predictive function (Bandura, 1977a, 1977b). Likewise, contingent experiences generate expectations not connections between stimuli and responses (Bandura, 1977b). Within Bandura’s conceptual model, he made a clear distinction between efficacy expectations and outcome expectations. While outcome expectancy is one’s appraisal that a specific behavior will result in certain outcomes, an efficacy expectation is the belief that one is capable of successfully executing the behavior required to produce the outcomes (Bandura,
It is critical to distinguish between these two types of expectations, as a person can believe that a given course of action will lead to certain outcomes. Conversely, doubts about his ability to perform the required behaviors have the potential to hamper his enactment of the behaviors.

Bandura (1977a) posits that one’s expectations of personal mastery dually affect one’s initiation of a behavior and how much effort is exerted on an activity. Thus, the stronger a person’s self-efficacy beliefs, the more effort he will put into a task; conversely, a less efficacious individual will not be as actively involved in a task. However, apart from certain capabilities, expectation alone will not produce the desired performance. Efficacy beliefs have the potential to influence individual’s thought patterns and emotional responses (Pajares, 1996).

**The Mechanism of Personal Agency.** Mechanisms of personal agency enable individuals to make causal offerings to their own psychosocial functioning (Bandura, 1997). Personal self-efficacy is a salient mechanism of personal agency. Individuals’ beliefs in their ability to attain desired outcomes and inhibit undesired ones provide a very potent incentive for the development and exercise of personal control. Bandura (1986) posited that individuals only have a strong reason to fear events when they cannot predict or exercise control over them. According to Bandura’s (1997) idea of reciprocal determinism, human agency functions within an interdependent causal framework involving the triadic reciprocality of personal factors, behavior, and environment. As shown in Bandura’s (1997) conception of
triadic reciprocality (see Figure 2), personal factors in the form of cognitive, affective, and behavioral events, behavioral, and environmental events generate interactions that influence one another in a bidirectional manner. Their overall influence varies across activities and under different circumstances (Bandura, 1997).

Figure 2. Interdependent relationship between the interacting determinants in Bandura’s conception of triadic reciprocality

Bandura (1977) proposed that self-efficacy beliefs vary in magnitude, generality, and strength. Self-efficacy beliefs may differ in magnitude, which refers to the degree to task difficulty. Therefore, when tasks are arranged based on their level of difficulty, individuals’ self-efficacy beliefs may be restricted to simple tasks, moderately difficult tasks, or very difficult tasks. Self-efficacy scales have been constructed to measure perceived self-efficacy across a broad range of task demands, thus identifying the upper and lower limits of individuals’ perceptions of their capabilities (Bandura, 1989). The generality of self-efficacy beliefs refers to the transferability of self-efficacy beliefs across tasks. For example, can a student’s self-efficacy be transferred from biology to chemistry? Last, self-efficacy beliefs may vary in strength, which is a measure of the amount of certainty a person has in performing a task. Thus, individuals with strong efficacy-beliefs will persevere in the face of
challenges when performing a task.

**Sources of Self-efficacy.** Self-efficacy is fairly malleable and differs in response to learning experiences (Hughes, Galbraith, & White, 2011). As individuals acquire new information and experiences over time their self-efficacy judgments change (Gist & Mitchell, 1992). Self-efficacy beliefs stem from four sources of information: performance accomplishments, vicarious experience, verbal persuasion, and physiological states (Bandura, 1977a). According to Bandura (1988), self-appraisal involves weighing and integrating different sources of information to form self-efficacy, with the overall weighing of information differing across domains of functioning and situational circumstances.

**Performance accomplishments/mastery experiences.** Performance accomplishments heavily influence efficacy expectations because they are based on a person’s authentic mastery experiences (Bandura, 1977a). Enactive mastery experiences are “the most influential source of efficacy information because they provide the most authentic evidence of whether one can master whatever it takes to succeed” (Bandura, 1997, p. 80). The more frequently individuals experience success, the higher their mastery expectations; conversely, repeated failures tend to lower mastery expectations. Failure has the potential to augment self-efficacy beliefs when individuals attribute their lack of success to ineffective strategy use and not an inability to perform (Bandura, 1986). Bandura (1997) explains that it is not the performance successes or failures themselves that augment or attenuate efficacy beliefs. The changes one may experience in his self-efficacy beliefs result from cognitive processing of
diagnostic information that the performances send about the person’s ability (Bandura, 1997). Overall, the impact of the performance relies on the individual’s interpretation of the performance. Many individuals perceive effort as inversely related to capability; therefore, to experience success on a challenging task with little effort equates high capability (Bandura, 1986). Moreover, people tend to infer high self-efficacy when they only have to exert little effort to successfully complete a difficult task (Bandura, 1986).

**Vicarious experience.** Individual’s efficacy beliefs may also stem from vicarious experience. When a person observes other people who are similar to him/herself perform a challenging task without negative consequences, expectations of having the same capability are enhanced (Bandura, 1977a, 1986). Efficacy beliefs are generated from vicarious experience because the individual and the models possess similar personal characteristics that are assumed to be predictive of performance, and not simply from a comparison of their performance (Bandura, 1986). The efficacy information conveyed by vicarious experience tends to be less dependable and weaker than information conveyed by mastery experiences (Bandura, 1977a).

**Verbal or Social persuasion.** The third source of self-efficacy beliefs is social persuasion by individuals who possess some amount of evaluative competence (Bandura, 1977a, 1986). Usually verbal persuasion takes on the form of evaluative feedback conveyed to one who is performing a task (Bandura, 1997). The efficacy of verbal persuasion in enhancing self-efficacy beliefs lies in the credibility of the verbalizer or persuader, as well as
their depth of knowledge about the nature of the tasks (Bandura, 1986). Individuals tend to believe information conveyed by highly skilled individuals or more skilled than themselves (Bandura, 1997). While verbal persuasion tends to be the most widely used source of self-efficacy, it is the weakest source of self-efficacy (Warner, Shuz, Knittles, Ziegelmann, & Wurm, 2011). Verbal persuasion does not exert a long-lasting effect on enhancing self-efficacy (Bandura, 1977, 1997). Studies have reported that verbal persuasion is primarily targeted at increasing outcome expectations rather than boosting self-efficacy (Bandura, 1977). Wise and Trunnell (2001) reported that verbal persuasion is only effective in strengthening self-efficacy beliefs when it follows a performance accomplishment. In some studies, verbal persuasion did not predict or have an effect on increasing self-efficacy (Warner, Shuz, Knittles, Ziegelmann, & Wurm, 2011; Purzer, 2011).

**Physiological and affective states.** Physiological and affective states are sources of self-efficacy, as people tend to rely on somatic information to judge their capabilities (Bandura, 1977a). High emotional arousal tends to limit performance. According to social learning theory, it is the cognitive appraisal of arousal that promotes the level and direction one’s motivation to carry out a particular behavior (Bandura, 1977a). While some cognitive appraisals of one’s physiological state may be invigorating, other appraisals of the exact same state might have an opposite effect.

Gist and Mitchell’s (1992) proposed model (see Figure 3) of the determinants of self-efficacy addresses the question of how these judgments both form and change over time.
Specifically, Gist and Mitchell’s model focuses on Bandura’s hypothesized four sources of information. Once information is received from these sources, it undergoes three types of assessment: analysis of task requirements, attributional analysis of experience, and assessment of personal and situational resources/constraints. Of these three assessment processes, analysis of task requirements and attributional analysis of experience are categorized as antecedent processes. During the analysis of task requirements, the individual produces inferences about what is needed to perform at different levels. Attributional analysis of the experience involves the individual’s attributions regarding why a specific performance level occurred (i.e. “In the past, I have made good predictions of my success which I attribute to my science skills and/or hard work”). Mitchell and Gist (1992) explain that these two types of analysis provide much needed data in the formation of self-efficacy judgments, but it is not sufficient; therefore, the individual must examine himself and the availability of resources for and barriers to performing a specific task at different levels.
Self-efficacy and Context. Self-efficacy beliefs are not contextless judgments of competence, but are very task and domain-specific (Bandura, 1986; Pajares 1996). Thus, global self-efficacy measurements weaken the effects of these appraisals. In order to increase the predictive power of self-efficacy beliefs, they must be assessed at the ideal level of specificity that corresponds to the task and the domain of functioning under investigation (Pajares, 1996). Zimmerman (2000) describes self-efficacy beliefs as being multidimensional in form and varying on the basis of the domain of functioning. Furthermore, self-efficacy beliefs are very sensitive to differences in performance context (Zimmerman, 2000), such as an African American student learning in a class that consists of majority White students compared to one of primarily African American students. In consideration of the influence
exerted by environments or society, researchers have reported that racial inequality (i.e. blocked opportunities and institutional barriers resulting from systemic racism or discrimination) influences self-efficacy (Hughes & Demo, 1989; Oyserman, Harrison, & Bybee, 2001).

With regards to my dissertation and domain specificity of self-efficacy beliefs, I have focused on the body of literature covering science self-efficacy beliefs. According to Britner and Pajares (2006), science self-efficacy is a learner’s belief in his or her ability to successfully perform science tasks, courses, or activities. Likewise, students’ science self-efficacy beliefs influence their decisions to engage in science-related activities, the amount of effort they exert on performing science-related tasks, the degree to which they persevere when facing challenges while performing science-related tasks, and the amount of success they experience in science (Zeldin & Pajares, 2000; Britner & Pajares, 2006). Science self-efficacy has proven to be a valuable construct in both predicting students’ continuation in science-related disciplines (Britner, et al., 2012).

While researchers have established that self-efficacy is a strong predictor of academic performance, empirical research on the relationship between self-efficacy and science performance is very limited (Britner & Pajares, 2006; Britner, et al., 2012; Robnett, Chemers, & Zurbriggen, 2015; Zeldin & Pajares, 2000). Studies have provided empirical evidence that science self-efficacy is positively correlated with science achievement and science related choices across the grade spectrum (Britner & Pajares, 2006). Through her study of first year
nursing students, Andrew (1998) found that science self-efficacy is a strong predictor of science performance. Researchers have also reported that collaborative learning models in science at the university level promote the development of self-efficacy beliefs, thereby allowing for greater predictability of STEM career success (Britner, et al., 2012). Larson et. al (2015) conducted a longitudinal study to evaluate if mathematics/science self-efficacy significantly predicts graduating with a bachelor’s degree in a STEM discipline. They found that when controlling for prior high school performance (high school grade point average) and aptitude (American College Test or Scholastic Assessment Test scores), mathematics/science self-efficacy makes a significant contribution to academic persistence toward graduation from a STEM program of study.

Investigations into science self-efficacy are relatively limited and the proposed models for sources of self-efficacy fail to take into consideration any racial variations between learners. While researchers are aware that racial identity influences self-efficacy beliefs (Collins & Lightsey, 2001; Hughes & Demo, 1989; Oyserman, Harrison & Bybee, 2001), there have not been any investigations into the influence racial identity has on the science self-efficacy beliefs of African American students. There is only a small pool of research that focuses on the science self-efficacy beliefs of African American students but there are no models to conceptualize how their lived experiences contribute, in particular how to acts of racism or situations when their race is salient interfere with the influence exerted from Bandura’s proposed sources.
The Role of Historically Black Colleges and Universities (HBCUs)

The context in which students learn science is critical to the development of their varied identities, as this process involves a strong interplay between social dimensions and the individual. Specifically, identity is socially mediated and determined by our own intentional action or agency (Murrell, 2009). Thus, attention should be given to the role universities or institutions of higher learning play in the formation of identity for African Americans. With regards to self-efficacy, Bandura (1977) hypothesized that there are four primary sources of self-efficacy: verbal persuasion, enactive mastery, vicarious experience, and physiological and emotional state. Each of these sources are present to some degree in the college context, thus it is important to evaluate how students are exposed to these sources at the college level. In lieu of these points, a review of the existing literature of the role the institution plays in promoting the development of self-efficacy, racial identity, and science identity will be provided in this section. With regard to institution type, this review will solely focus on the ethnoracial makeup of the institution by exploring Historically Black Colleges and Universities (HBCUs).

Historically Black institutions of higher learning are essentially an outcome of discrimination against Black people in America. In fact, it was considered a crime to teach Black slaves how to read or write in every U.S. state, with the exception of Tennessee (Gasman & Hilton, 2012). The rationalization to deny Black people an education was rooted in two ideologies: (1) Black people were considered inferior to White people and (2)
educating Black people would arouse a desire to compete with White people in various arenas (Gasman & Hilton, 2012). Prior to the emancipation of slaves, most Whites believed that giving African Americans an opportunity to attend college would threaten the existence of slavery (Kim, 2002). Despite these beliefs, White religious missionaries and some Black churches established Black colleges primarily to train teachers for the segregated schools (Gasman, 2007; Newkirk, 2012). Thus, the first Black colleges were established in the mid-1800s (Kim, 2002; Newkirk, 2012), with the Institute for Colored Youth being the established HBCU (Gasman & Hilton, 2012).

While the efforts of the White missionaries appeared to be benevolent, their actions were actually an example of interest convergence, a central tenet of Critical Race Theory (Bell, 1980; Gasman & Hilton, 2012). According to Bell’s (1980) notion of interest convergence, “The interest of blacks in achieving racial equality will be accommodated only when it converges with the interests of whites” (p. 523). Hence, African Americans were able to further their education at the Black colleges established by white missionaries, because these missionaries hoped such an effort to promote the conversion of formerly enslaved Blacks to Christianity (Gasman, 2007). More explicitly, the White missionaries pushed the idea that uneducated Blacks would be a threat to White society, especially if they lacked Christian values (Gasman & Hilton, 2012). Therefore, HBCUs would not only allow for training in liberal arts, but would provide Blacks with an opportunity to study the Bible and become knowledgeable of the central principles of Christianity (Gasman & Hilton, 2012).
Following the Civil War, additional Black colleges were established with the intent of providing education to newly freed slaves (Redd, 1998). Thus, majority of the institutions were established in southern states, and were funded without state government support (Redd, 1998). Black colleges were transformed in 1890 in response to the adoption of the second Morrill Land Grant Act, which designated funds for the establishment of public higher learning institutions that implemented agricultural and mechanical arts curricula; most importantly, making higher education accessible to former slaves (Gasman, 2007). Furthermore, this land grant act lead to the establishment of additional historically Black land grant colleges. Today there are a total of 103 historically Black institutions of higher learning, making up just three percent of the nation’s institutions of higher learning (National Center for Education Statistics, 2006).

The Higher Education Act of 1965 defines an HBCU as “…any historically black college or university that was established prior to 1964, whose primary mission was, and is, the education of black Americans” (National Center for Education Statistics, 2006). Prior to the Brown v. Board of Education decision in 1954, the majority of Black students were enrolled in HBCUs (Allen, 1992). However, the landscape of HBCUs changed following this decision, as more Black students began to enroll in PWIs and other racial groups began attending HBCUs (Newkirk, 2012). Disparities in the racial composition and academic achievement of students at HBCUs and PWIs can be attributed to the unique mission of Black colleges (Allen, 1992). Historically, HBCUs tend to enroll students who otherwise
would not be able to attend an institution of higher learning due to financial, social, and political hurdles (Allen, 1992). These institutions take great pride in their ability to equip financially disadvantaged and academically underprepared students for graduate schools and their chosen professions (Allen, 1992).

While HBCUs only make up a small percentage of the nation’s higher education institutions, they graduate close to twenty percent of African Americans who earn undergraduate degrees (National Center for Education Statistics, 2006). Significantly, HBCUs have produced a disproportionately high number of African American graduates in STEM (Shorette & Palmer, 2015), and are successful in providing African American students with a stronger sense of self (Fries-Britt & Turner, 2002; Van Camp, Barden, Sloan, & Clarke, 2009). Between 2002-12, bachelor’s degrees in science disciplines were awarded to 453,489 African Americans by all institutions, while 94,950 of those bachelor’s degrees were awarded by HBCUs (NSF, 2015); therefore, HBCUs awarded approximately 21 percent of the science degrees awarded to African Americans during this timeframe. Of the top 20 institutions awarding science and engineering degrees to African Americans between 2008-2012, eight of the institutions were HBCUs (NSF, 2015). As shown through these statistics, HBCUs play a very critical role in the production of African American scientists, which is due to the institutional culture and climate.

With regards to contextual differences between HBCUs and PWIs, it is widely believed that their environments vary in ways that either impede or promote the academic
achievement of African American students (Allen, 1992). More specifically, qualitative data suggests that HBCUs are warmer, more nurturing, community-oriented, student-centered, promote a greater sense of belonging, enhance self-efficacy beliefs, and augment racial pride (Allen, 1992; Palmer, Davis, & Maramba, 2010; Shorette & Palmer, 2015; Sloan, & Clarke, 2009; Spurgeon & Myers, 2010; Van Camp, Barden). Moreover, studies indicate that attending HBCUs positively influences a student’s self-concept (Shorette & Palmer, 2015; Van Camp, Barden, Sloan, & Clarke, 2009). Take the case of a qualitative study of African American HBCU students conducted by Shorette and Palmer (2015) which illuminates how HBCUs increase students’ self-efficacy beliefs through vicarious experiences. Through in-depth interviews of six African American males who successfully persisted to graduation from an HBCU, Shorette and Palmer gained insight into how the HBCU experiences of these males promoted the development of their self-confidence. Specifically, the participants expressed that seeing African American faculty and peers experience success within their educational domain helped to strengthen their own belief in their ability to achieve similar or greater success (Shorette & Palmer, 2015). Additionally, the participants in Shorette and Palmer’s (2015) study expressed how their exposure to race and inequality at their HBCU shaped their perceptions of race and the manner in which they navigate their way through racist systems.

According to findings presents by Chang et al (2008), there is a difference in the persistence rate in biomedical sciences for students who attend HBCUs compared to those
who attend PWIs. Their findings show a negative correlation between the level of selectivity and rate of persistence for PWIs; however, there is a positive correlation between the level of selectivity and persistence for HBCUs. Therefore, Black students who attend highly selective HBCUs have a higher chance of completing their STEM courses; thereby, increasing their chances to complete a STEM degree. Chang et al (2008) concluded that highly selective HBCUs seem to take a different approach than PWIs, in that, HBCUs tend to place less emphasis on “weeding students” out of gatekeeper science courses. Alternatively, HBCUs take time to socialize and cultivate the abilities of students in an effort to improve their chances of succeeding in the sciences (Chang et al, 2008). Historically, HBCUs have established a reputation of providing Black students with a learning environment that fortifies their abilities (Gasman, Baez & Sotello Viernes, 2007).

With regard to racial identity development, findings from a quantitative study of 67 Black undergraduates at an HBCU conducted by Van Camp et al. (2009) indicated that a significant number of Black students attend HBCUs because they desire to develop their racial identity and they are confident that the university will help to develop their racial identity. Findings from their study show that race-related reasons for attending an HBCU are linked to future development of racial identity and race-related behavioral aims instead of social or academic behavior.

Through qualitative methods, researchers have discovered that African American students on HBCU campuses experience a high degree of faculty interaction and possess
A strong sense of community (Allen, 1992; Fries-Britt & Turner, 2002; Jett, 2013; Palmer, Davis, & Maramba, 2010; Shorette & Palmer, 2015). African American male participants in Palmer, Davis, and Maramba’s (2010) study discussed how faculty encouraged them verbally and gave them opportunities to demonstrate their competence. In accordance with Palmer et al.’s (2010) findings, Fries-Britt and Turner (2002) indicated that students believed faculty “went far beyond the call of duty to provide encouragement and support” (p.321). Similarly, participants in Shorette and Palmer’s (2015) study described the professors in their departments as being individuals who “provided extraordinary support” (p. 24). This type of interaction between African American students and faculty are aligned with both Bandura’s (1977) hypothesized sources of self-efficacy, as well as Carlone and Johnson’s (2007) identity model. My assumption is that through social persuasion from a credible faculty member the students’ self-efficacy beliefs increase, while opportunities to demonstrate competence help to develop their identity.

One of the distinguishing features of HBCUs is their potential to foster social and academic collaboration among a large group of African American college students (Jett, 2013). A body of research indicates that African American students attending HBCUs experience strong peer networks that contribute to their success confidence and sense of belonging (Allen, 1992; Jett, 2013; Palmer, Davis, & Maramba, 2010). Palmer, Davis, & Maramba (2010) concluded that peer groups influence African American students attending HBCUs desire to perform well academically, as students become affiliated with a group of
individuals who are pursuing academic success.

In summary, HBCUs have a rich history in the educational and racial identity development of African Americans. As discussed in this section, HBCUs provide a nurturing and supportive environment that is not typically experienced by African American students who attend PWIs. Moreover, this type of environment experienced at HBCUs has resulted in a high number of degrees awarded to African Americans in various science disciplines. Thus, this section of the literature review provides a strong rationale for situating this study within the context of HBCUs.

**Chapter Summary**

If we are to understand the persistence of African American students in science, we must gain insight into how they perceive themselves ( racially and academically) along with how they feel about their ability to perform science-related tasks. As demonstrated through this review, the body of research exploring the key constructs of science self-efficacy and science identity is limited. While both general self-efficacy and personal identity have been researched heavily for several decades, the merger of these constructs with the field of science has just recently ignited research in this direction. Moreover, investigations surrounding these constructs as related to their development within African Americans are few and far between. More research is needed in this regard, if we are to produce African American scientists who are equipped to partake in the anticipated job explosion in STEM within the next 10 to 20 years.
CHAPTER III: RESEARCH DESIGN AND METHODOLOGY

This chapter provides a description of the population and sample, sampling procedures, instrumentation, data collection procedures, and analysis of the study. According to Chen (Johnson, Onwuegbuzie, and Turner, 2007) mixed methods is “a systematic integration of quantitative and qualitative methods in a single study for purposes of obtaining a fuller picture and deeper understanding of a phenomenon. Mixed methods can be integrated in such a way that qualitative and quantitative methods retain their original structures and procedures (pure form mixed methods). Alternatively, these two methods can be adapted, altered, or synthesized to fit the research and cost situations of the study” (p. 119). A concurrent mixed methods design (QUANT + qual) was used for this dissertation study. More specifically, greater emphasis was placed on the quantitative component while the qualitative was utilized to further elaborate the larger quantitative design (Creswell & Clark, 2011); therefore, this approach enabled me to address different research questions. Overall, the theoretical drive of this study is deductive, thus quantitative methods best answer the majority of the research questions (Morse, 2010). Moreover, Critical Race Theory was selected as the guiding worldview for this mixed methods study because it is most suitable to authentically address each of the research questions; therefore, employing a concurrent mixed methods design provides an opportunity to address this theoretical viewpoint at diverse levels.
Justification of Concurrent Mixed Methods

An approach consisting of quantitative and qualitative data sources produces the desired results of this study. The purpose for the quantitative data was to yield a numeric description that may be generalized to the specific population and provide tests of prediction and correlation. The purpose of the qualitative data was to understand and investigate the lived experiences or reality of the target population. The qualitative findings from this study were significant because they gave me insight into the perceptions of African American students who attend HBCUs with great detail. Thus, the concurrent design allowed me to collect different, yet complementary data on the interaction of three different constructs and the perceptions of how HBCUs promote these interactions from African American students within this unique context (Morse, 1991). In order to gain a holistic understanding, it was vital to mix the two data sets (DeCuir-Gunby & Shutz, 2017). Essentially, merging the two data sets brought together the strengths and weaknesses of each method, resulting in a more rigorous study (Patton, 1990).

Study Design

Prior to beginning the study, approval was obtained from the North Carolina State Institutional Review Board (IRB), as well as the IRB for each of the five HBCUs involved in this study. The study’s methodological approach included: 1) collecting both quantitative and qualitative data concurrently; 2) analyzing the quantitative and qualitative data; 3) mixing the results of the two data sets; and 4) interpreting to what extent the quantitative and qualitative
data converge to provide a fuller understanding of the problem (DeCuir-Gunby & Shutz, 2017; Creswell, 2009). A greater priority was allocated to the quantitative aspect of the study (Creswell, 2009). A visual representation of the procedures for this concurrent mixed methods design is presented in Figure 4.

Figure 4. Schematic of Concurrent Mixed Methods Design
The theoretical framework and research design for this study allowed me to address the following research questions and hypotheses (see Figure 5 for visual representation):

1. What is the relationship between the science self-efficacy beliefs, science identity, and racial identity of African American students attending HBCUs?
   a. $H_0$: There is no statistically significant relationship between racial identity, science identity and science self-efficacy beliefs of African American students attending HBCUs.
   b. $H_1$: The racial identity of African American students attending HBCUs will moderate the association between science identity and their science self-efficacy beliefs.
   c. $H_2$: There will be a positive correlation between the racial identity of African American students attending an HBCU and their science identity.

2. To what extent does science identity, science self-efficacy, and racial identity influence the science achievement of African American students attending HBCUs?
   a. $H_0$: Racial identity, science identity, and science self-efficacy beliefs do not have an effect on the science achievement of African American college students attending HBCUs.
   b. $H_1$: The racial identity of African American students attending HBCUs will moderate the association between science self-efficacy beliefs and their science achievement.
c. $H_2$: The science identity of African American students at HBCUs will mediate the effect of science self-efficacy on their college science achievement.

d. $H_3$: There will be a positive correlation between science self-efficacy beliefs of African American students attending an HBCU and their science identity.

3. To what extent do the pre-college experiences of African American students attending HBCUs influence their science self-efficacy beliefs, science identity, racial identity, and college science achievement?

   a. $H_0$: The pre-college experiences of African American students attending HBCUs do not influence their science self-efficacy beliefs, science identity, racial identity, and science achievement.

   b. $H_1$: The pre-college experiences of African American students attending HBCUs will moderate the effects of their science identity on college science achievement.

   c. $H_2$: There is a positive correlation between the pre-college experiences of African American students attending HBCUs and their science self-efficacy beliefs.

4. What is the role of the HBCU context in supporting/affirming/facilitating the development of racial identity, science identity and science self-efficacy beliefs?
Sample and Interview Participants’ Profiles

The participants for the quantitative aspect of this study were \( n = 346 \) self-identified African American undergraduate students from five historically Black colleges and universities (HBCUs) located in the southeastern United States (See Table 2 for frequencies related to participants of the quantitative component). The students were primarily Biology \( (n = 276) \), Chemistry \( (n = 36) \), Physics \( (n = 18) \), or Pharmaceutical Sciences \( (n = 15) \). With regards to classification, I chose to not include freshmen, as they would not have experienced the institutional context enough to show its influence; therefore, the sample included sophomores \( (n = 118) \), juniors \( (n = 106) \), and seniors \( (n = 99) \). While 22 freshman and two graduate students attempted to complete the survey, they were not included in the analyses.
The age of the participants in the sample ranged from 17 to 53 years with an average of 20.85 (SD = 3.45). The majority of the participants were female (n = 267, 67%), while 79 (20%) were males.

Student participants self-reported pre-college and college experiences with science on the demographic survey. The number of AP or IB science courses taken in high school ranged from 0.00 to 20.00, with an average of 1.56 (SD = 2.46). The number of AP or IB math courses taken in high school ranged from 0.00 to 18.00, with an average of 0.98 (SD = 1.71). The number of science extracurricular activities in high school ranged from 0.00 to 10.00, with an average of 0.71 (SD = 1.28). Participants’ reported high school GPAs that ranged from 2.00 to 4.90, with an average of 3.42 (SD = 0.53). Participants’ reported college GPAs that ranged from 2.00 to 4.00, with an average of 2.87 (SD = 0.45). Participants’ reported college science GPAs that ranged from 1.30 to 4.00, with an average of 2.42 (SD = 0.59). Participants in the sample reported that they had completed from 0.00 to 5.00 summer science-related programs or internships, with an average of 0.60 (SD = 0.94).
Table 2

*Frequency Table for Major, School, Highest Science in High School, and Highest Math in High School*

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**Highest Science in High School**

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<td>Earth Science (Regular, Honors, AP, IB)</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Science (Regular, Honors, AP, IB)</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Forensic Science/Forensic Science Honors</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Multiple AP Science Courses</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Multiple Honors Science Courses</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>Physical Science</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Physics/Chemistry</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Physics (Regular, Honors, AP, IB)</td>
<td>40</td>
<td>10</td>
</tr>
</tbody>
</table>

**Highest Math in High School**

<table>
<thead>
<tr>
<th>Subject</th>
<th>23</th>
<th>6</th>
</tr>
</thead>
</table>
Table 2 Continued

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Participants</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry/Geometry Honors</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Multiple AP Math Classes</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>53</td>
<td>13</td>
</tr>
<tr>
<td>Pre-Algebra (Regular, Honors, AP, IB)</td>
<td>23</td>
<td>6</td>
</tr>
<tr>
<td>Pre-Calculus/Calculus (Regular, Honors, AP, IB)</td>
<td>163</td>
<td>40</td>
</tr>
<tr>
<td>Statistics/Statistics Honors/Probability &amp; Statistics/</td>
<td>26</td>
<td>6</td>
</tr>
<tr>
<td>AP Statistics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Due to rounding errors and missing responses, percentages may not equal 100%.

Participants’ Institutions. The participants in this study were enrolled in one of five HBCUs located in a southeastern state. To maintain the anonymity of the participating institutions, I have assigned pseudonyms; therefore, they will be referred to as Franklin State University, Jackson B. Southerland University, Smith University, North Central M&T State University, and Calvin University. While all of the institutions have biology and chemistry programs, not all of them have physics programs. The North Central M&T State University has a total of 458 biology students (427 undergraduates and 31 graduates), 83 chemistry students (73 undergraduates and 10 graduates), and 49 physics students (42 undergraduates and 7 graduates). Calvin University has a total of 400 biology and biomedical sciences students, 58 chemistry and biochemistry students, 91 mathematics and physics students, and 158 pharmaceutical sciences students. Smith University is one of the United States oldest HBCUs in the country. Jackson B. Southerland has 175 biology majors and 19 chemistry majors enrolled in Jackson B. Southerland. Table 3 provides a description of each
participating institution.

Table 3

*Description of Participating Institutions*

<table>
<thead>
<tr>
<th>Participating Institution</th>
<th>Institution Type</th>
<th>Student Population</th>
<th>Student Demographics</th>
<th>Faculty-Student Ratio</th>
<th>Degrees Awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackson B. Southerland</td>
<td>Private</td>
<td>1,344 students</td>
<td>74% Black or African American</td>
<td>12:1</td>
<td>Bachelor’s Master’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>61% female; 39% male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Central M&amp;T State University</td>
<td>Public</td>
<td>11,177 students</td>
<td>77.8% Black or African American</td>
<td>19:1</td>
<td>Bachelor’s Master’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>57% female; 43% male</td>
<td></td>
<td>Doctoral</td>
</tr>
<tr>
<td>Calvin University</td>
<td>Public</td>
<td>8096 students</td>
<td>78% Black or African American</td>
<td>16:1</td>
<td>Bachelor’s Master’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>66% female; 34% male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Franklin State University</td>
<td>Public</td>
<td>5,899 students</td>
<td>65% African American</td>
<td>17:1</td>
<td>Bachelor’s Master’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>68% female; 32% male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smith University</td>
<td>Private</td>
<td>1,713 students</td>
<td>71.2% African American</td>
<td>14:1</td>
<td>Bachelor’s Master’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>57% female; 43% male</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Recruitment of Participants.** In order to receive permission to recruit students, I submitted applications for approval from the Institutional Review Board each of the five HBCUs included in this study. Once I received approval from each institution, I secured a primary point of contact for each department within each institution. In most cases, the primary point of contact provided the contact information for various faculty members within the department who would potentially provide the opportunity to administer the survey during one or more classes/laboratories. Once professors provided the day and time for a site visit, I traveled to the institution to recruit students face-to-face by providing them a brief
overview of the study. With regards to North Central M&T, the biology students were recruited through announcements delivered through the department’s Blackboard organization or email. Additionally, the recruitment letter was delivered via email to students in the chemistry and physics departments at North Central M&T.

In order to recruit students for the qualitative aspect, convenience sampling was employed. These students were recruited during site visits to the various institutions when I administered the paper-based version of the survey; however, biology students did not participate from one of the institutions due to a conflict of interest stated in the IRB. Students were informed of the opportunity to participate in the interview component before they were given the paper-based survey, and asked after the survey’s administration to provide their contact information if they were interested in participating in the interview.

**Instrumentation**

A variety of instruments were used for this study. During the quantitative phase of this study, students responded to questions on three different instruments (See Appendix C): Multidimensional Inventory of Black Identity (MIBI) (Sellers, Smith, Shelton, Rowley, & Chavous, 1998), Science Identity Scale (Chemers et al., 2011), and Science Self-efficacy Inventory (adapted from Nietfeld, Cao, & Osborne, 2006; Nietfeld, Shores, & Hoffman, 2014). Also, students completed a demographics questionnaire. Cronbach alpha coefficients were calculated for the scales included in the analysis (See Table 4). Cronbach’s alpha coefficients were evaluated using the following benchmarks: > .9 excellent, > .8 good, > .7
acceptable, > .6 questionable, > .5 poor, and ≤ .5 unacceptable (George & Mallery, 2016).

Table 4

*Reliability Table for Science Identity, Science self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard*

<table>
<thead>
<tr>
<th>Scale</th>
<th>No. of Items</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Identity</td>
<td>5</td>
<td>0.85</td>
</tr>
<tr>
<td>Science self-efficacy</td>
<td>8</td>
<td>0.84</td>
</tr>
<tr>
<td>Centrality</td>
<td>8</td>
<td>0.78</td>
</tr>
<tr>
<td>Nationalist</td>
<td>9</td>
<td>0.74</td>
</tr>
<tr>
<td>Public Regard</td>
<td>6</td>
<td>0.79</td>
</tr>
<tr>
<td>Assimilation</td>
<td>9</td>
<td>0.66</td>
</tr>
</tbody>
</table>

The qualitative component of this study followed a semi-structured interview schedule (See Appendix F).

**Multidimensional Inventory of Black Identity (MIBI).** In order to explore racial identity development, I used the Multidimensional Inventory of Black Identity (MIBI), an operationalization of the Multidimensional Model of Racial Identity (MMRI) (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). The Multidimensional Inventory of Black Identity was developed to examine the multidimensional nature of Black identity (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). The scale measures three of the four dimensions proposed by the MMRI: *racial salience, racial centrality, racial regard,* and *racial ideology.* These racial identity dimensions are represented through the use of seven subscales: Centrality, Private
and Public Regard, Nationalist ideology, Oppressed Minority ideology, Assimilationist ideology, and Humanist ideology (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). The MIBI consists of 54 items featuring a 7-point Likert scale format. Each subscale consists of eight questions, with some requiring reverse scoring to ensure consistent scoring.

The MIBI has demonstrated validity and reliability of the MMRI, in that Sellers et. al (1997) reported Cronbach’s alphas for scores ranging between 0.55 to 0.79 in samples of students from both HBCUs and predominantly White institutions (PWIs). Similarly, Vandiver, Cross, Worrell, and Fhagen-Smith (2002) reported internal consistency scores for the MIBI between 0.58 to 0.78, while Simmons, Worrell, and Berry (2008) report Cronbach’s alphas that range from 0.51 to 0.87. For the purpose of this study, I only examined four dimensions of racial identity based on the MIBI: centrality, public regard, assimilationist ideology, and nationalist ideology. For three of the four subscales used in this study, Sellers et al (1997) reported the following Cronbach’s alphas for students attending HBCUs: centrality (0.75), assimilation (0.74), and humanist (0.69). In this study Cronbach’s alphas were found and indicated good reliability, except for the Assimilation scale. The Centrality scale had a Cronbach's alpha coefficient of 0.78. The Nationalist scale had a Cronbach's alpha coefficient of 0.74. The Public Regard scale had a Cronbach's alpha coefficient of 0.79. The coefficients for these scales indicated acceptable reliability. The Assimilation scale had a Cronbach's alpha coefficient of 0.66, which indicated questionable reliability for this study.
**Science Identity Scale.** Chemers et al. (2011) developed the Identity as a Scientist scale based on the Seller’s Multidimensional Model of Racial Identity/ Multidimensional Inventory of Black Identity, the work of Luhtanen and Crocker (1992) and interviews. The five-item scale was originally developed as a 5-point Likert format, but was modified to a 4-point format (1=strongly disagree and 4 = strongly agree) (Robnett, Chemers, & Zurbriggen, 2015). While this scale was just recently developed, the Cronbach’s alpha for internal consistency reliability for this scale ranges from 0.89 to 0.96 (Chemers et al., 2011; Robnett, Chemers, & Zurbriggen, 2015). In this study, for the Science Identity a Cronbach’s alpha of 0.85 was found; therefore, I was able to conclude that this scale has good reliability for this study.

**Science Self-efficacy Inventory.** The Science Self-efficacy Inventory is an adapted version of the Educational Psychology Self-efficacy Inventory (Nietfeld, Cao, & Osborne, 2006; Nietfeld, Shores, & Hoffman, 2014). This inventory consisted of eight items that are based on a five-point Likert scale. Scores from the inventory are summed to create a single composite score for each administration of the inventory. Nietfeld, Cao, & Osborne (2006) reported a coefficient alpha between 0.88 to 0.90. For my sample, I calculated a Cronbach's alpha coefficient of 0.84 for the Science Self-efficacy scale; therefore, this coefficient indicated a good reliability for the scale.

**Demographics Questionnaire.** The demographics questionnaire included questions regarding personal characteristics such as age, gender, major, and classification.
Additionally, questions captured information regarding their academic experiences such as number high school science/mathematics courses, rigor of high school science/mathematics courses (i.e. college preparatory, advanced placement, international baccalaureate, etc.), college science/mathematics courses, SAT/ACT MATH scores, participation in science camps/programs, high school grade point average (GPA), and college GPA.

**Interview Protocol.** For the qualitative component, convenience sampling was employed to recruit the interview participants \(n = 14\) (See Table 5 for participant profiles). Additionally, the semi-structured interviews provided an opportunity to gain a deeper understanding of the participants’ lived experiences and perceptions through the examination of questions that emerged throughout the interview process. An interview guide was followed to ensure that all of the essential topics were addressed (Creswell, 2007); however, probing questions were asked based on the responses of the students to the questions on the protocol.
Table 5

*Interview Participant Profile*

<table>
<thead>
<tr>
<th>Name</th>
<th>Classification</th>
<th>Gender</th>
<th>Institution</th>
<th>Major</th>
<th>Cum GPA</th>
<th>Career Aspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dennis</td>
<td>2nd degree - Junior</td>
<td>Male</td>
<td>Calvin University</td>
<td>Chemistry</td>
<td>4.0</td>
<td>Physician</td>
</tr>
<tr>
<td>Patricia</td>
<td>Junior</td>
<td>Female</td>
<td>Calvin University</td>
<td>Biology</td>
<td>4.0</td>
<td>Physician - Researcher</td>
</tr>
<tr>
<td>Latifah</td>
<td>Sophomore</td>
<td>Female</td>
<td>Calvin University</td>
<td>Pharm. Sci.</td>
<td>3.7</td>
<td>Pharmacist</td>
</tr>
<tr>
<td>April</td>
<td>2nd degree - Junior</td>
<td>Female</td>
<td>Calvin University</td>
<td>Chemistry/ Pharm. Sci.</td>
<td>3.0</td>
<td>Clinical Pathologist</td>
</tr>
<tr>
<td>Destiny</td>
<td>Junior</td>
<td>Female</td>
<td>North Central M&amp;T</td>
<td>Chemistry</td>
<td>3.46</td>
<td>Physician - Researcher</td>
</tr>
<tr>
<td>Alex</td>
<td>Junior</td>
<td>Male</td>
<td>North Central M&amp;T</td>
<td>Physics</td>
<td>2.8</td>
<td>Engineer</td>
</tr>
<tr>
<td>Mary</td>
<td>Junior</td>
<td>Female</td>
<td>North Central M&amp;T</td>
<td>Chemistry</td>
<td>3.88</td>
<td>Pharmacist</td>
</tr>
<tr>
<td>Hannah</td>
<td>Senior</td>
<td>Female</td>
<td>North Central M&amp;T</td>
<td>Physics</td>
<td>3.9</td>
<td>Medical Physicist</td>
</tr>
<tr>
<td>Josiah</td>
<td>Senior</td>
<td>Male</td>
<td>North Central M&amp;T</td>
<td>Physics/Civil Engin.</td>
<td>3.84</td>
<td>Air Force Officer – Engineer</td>
</tr>
<tr>
<td>Shannon</td>
<td>Senior</td>
<td>Female</td>
<td>North Central M&amp;T</td>
<td>Physics</td>
<td>3.20</td>
<td>Field Research</td>
</tr>
<tr>
<td>Tiffany</td>
<td>Sophomore</td>
<td>Female</td>
<td>Jackson B. Southerland</td>
<td>Biology</td>
<td>3.2</td>
<td>Zoologist</td>
</tr>
<tr>
<td>Chris</td>
<td>Junior</td>
<td>Male</td>
<td>Franklin State</td>
<td>Chemistry</td>
<td>3.3</td>
<td>Researcher</td>
</tr>
<tr>
<td>Omar</td>
<td>Sophomore</td>
<td>Male</td>
<td>Franklin State</td>
<td>Chemistry</td>
<td>3.94</td>
<td>Researcher</td>
</tr>
<tr>
<td>Aniyah</td>
<td>Senior</td>
<td>Female</td>
<td>Franklin State</td>
<td>Biology</td>
<td>3.5</td>
<td>Physician</td>
</tr>
</tbody>
</table>
Data Collection

Quantitative Data Collection. The quantitative survey questions were made available to participants in either an online format or paper-pencil format. The online version of the survey was developed using Qualtrics. A skip-to-end function was put in place for participants who were not African American, since the population of interest for this study are African Americans. Although the vast majority of the participants completed the survey using the paper-pencil version, I was responsible for keying each survey question response into Qualtrics.

Once IRB approval was obtained from each institution, I proceeded with contacting the faculty at each institution to request the opportunity to use 20 minutes of their class time to administer the survey. Therefore, I traveled to each of the five institutions on multiple occasions to administer the surveys. During the in-class visits, I provided students with a brief overview of the study, as well as the informed consent form. Students were asked to read the consent form and sign to indicate their willingness to participate in the study. I asked the students to position the consent form so that the signature side of the form was visible. The consent forms were collected and sealed in an envelope. The consent forms were placed in a file cabinet in a very secure location. The students were also informed that their participation was completely voluntary. I prepared two types of envelopes for each student: one envelope contained the survey while the other envelope contained an alternate activity. As I collected the informed consent forms, I gave the students an envelope based on their
decision to participate. The survey and alternate activity took relatively the same amount of
time to complete, thus students were not aware of who took the survey and who completed
the alternate activity. Once the students completed the survey or alternate activity, they
placed the item in the envelope. I collected the envelopes. The paper-pencil version also
contain a QR code at the end of the survey, which students were to scan to access the entry
page for a random drawing for a $25 gift certificate. Students who completed the survey
either online or in-class were eligible to enter into one of three random drawings for a $25
gift certificate.

In addition to collecting quantitative data using class visits, students completed the
survey through Qualtrics. Students from three institutions were sent the survey recruitment
letter via email and/or through Blackboard announcements. Several iterations of the email
and Blackboard method occurred from September 2016-February 2017. While traveling to
the five institutions was time consuming, collecting the survey data through class visits was
the more effective option.

**Qualitative Data Collection.** The qualitative data was collected through semi-
structured interviews from the sample of African American science students (n=14). This
approach allowed students to share their experiences as African American science students
enrolled at an HBCU; therefore, providing insight into the role of the HBCU environment in
developing or promoting the interactions of their racial identity, science identity, and science
self-efficacy beliefs. The interview questions focused on their pre-college experiences with
science, their understanding of what is means to be African American, their definition of a scientist, interactions with faculty and peers, and their science self-efficacy, and experiences that have shaped their science and racial identities (see Appendix F).

The interview day, time, and location was determined through either email or text correspondence with the participants. The interviews were conducted either by phone or face-to-face in a private space located on the various campuses. Prior to each interview, the participants were asked to review and sign an informed consent form (see Appendix E). Participants whose interviews were conducted by phone received the consent form via email, and were asked to sign and return via email prior to the interview. Participants whose interviews were conducted face-to-face were given the consent form in person. Each participant was reassured that the information they share during the interview would be kept confidential and that a pseudonym would be assigned to them. Moreover, they were informed that they had the right to end the interview at any point or skip questions that made them feel uncomfortable. With the permission of the participants, the interviews were audio recorded. The phone interviews were audio recorded using the application Tape-A-Call, while the face-to-face interviews were audio recorded using the iPad application Voice Record Pro. I recorded some notes on the interview script during the actual interview, and more detailed fieldnotes following the interview. The interview length ranged from 35-55 minutes.

Following the interview, each participant received a $10 gift certificate to a national retailer. The recordings of the interviews were stored in a secure online drive, which requires a two-
Data Analysis

Quantitative Data Analysis. All quantitative analyses were conducted using SPSS. I started the process by cleaning the data file, which initially involved a visual inspection of the cells for missing values (Osborne, 2013). After identifying the missing data, I made a decision on how to handle the missing data. Cases missing sufficient data to create a composite score for a scale were not given a score for the variable. In turn, they were omitted from any analysis related to the variable. Additionally, I screened the variables for outliers, normality, and linearity; therefore, ensuring that the data met distributional assumptions (Osborne, 2013). Prior to calculating composite scores, I reverse-scored the appropriate items from the racial identity and science self-efficacy scales in order to maintain consistency with the remaining items from the scores where higher scores reflected more positive responses.

Several steps were taken to properly analyze the quantitative data collected in this study. I created the following composite scores: Science Identity, Science self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard. The composite scores were calculated by creating a mean of the items from the instruments representing each variable. Thereafter, I examined each composite score for outliers. Scores outside the range of \( \pm 3.29 \) standard deviations from the mean were classified as univariate outliers (Tabachnick & Fidell, 2013). There were four outliers in Science Identity, two outliers in Science self-
efficacy, one outlier in Centrality, and one outlier in Assimilation. I did not examine any outliers on the Nationalist and Public Regard scales. The outliers were removed from each variable.

Participants’ Science Identity scores ranged from 1.80 to 4.00, with an average of 3.12 ($SD = 0.55$). Science self-efficacy scores in the sample ranged from 1.00 to 3.62, with an average of 1.77 ($SD = 0.54$). From the MIBI scale, the Centrality scores ranged from 1.62 to 7.00, with an average of 4.94 ($SD = 1.08$). The Assimilation scores ranged from 2.56 to 7.00, with an average of 4.86 ($SD = 0.79$). The Nationalist scores ranged from 1.67 to 7.00, with an average of 4.11 ($SD = 0.88$). The Public Regard scores ranged from 1.00 to 6.17, with an average of 3.46 ($SD = 1.03$). Table 6 presents the means and standard deviations for the continuous variables.

Cronbach alpha coefficients were calculated for the scales included in the analysis. Cronbach’s alpha coefficients were evaluated using the guidelines suggested by George and Mallery (2016). Frequencies and percentages were calculated for the categorical variables included in the analysis (see Table 2). Means and standard deviations were calculated for the continuous variables included in the study (see Table 6). A Pearson correlation analysis was conducted among Science Identity, Science Self-Efficacy, Centrality, Assimilation, Nationalist, and Public Regard. Additionally, moderation and mediation analyses, as well as regression analyses, were conducted to address either research question 1, 2, or 3.
Table 6

Means and Standard Deviations for Continuous Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>n</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>20.85</td>
<td>3.45</td>
<td>349</td>
<td>17.00</td>
<td>53.00</td>
</tr>
<tr>
<td>AP/IB Science</td>
<td>1.56</td>
<td>2.46</td>
<td>301</td>
<td>0.00</td>
<td>20.00</td>
</tr>
<tr>
<td>AP/IB Math</td>
<td>0.98</td>
<td>1.71</td>
<td>291</td>
<td>0.00</td>
<td>18.00</td>
</tr>
<tr>
<td>Science Extracurricular</td>
<td>0.71</td>
<td>1.28</td>
<td>292</td>
<td>0.00</td>
<td>10.00</td>
</tr>
<tr>
<td>High School GPA</td>
<td>3.42</td>
<td>0.53</td>
<td>305</td>
<td>2.00</td>
<td>4.90</td>
</tr>
<tr>
<td>College GPA</td>
<td>2.87</td>
<td>0.45</td>
<td>306</td>
<td>2.00</td>
<td>4.00</td>
</tr>
<tr>
<td>College Science GPA</td>
<td>2.42</td>
<td>0.59</td>
<td>263</td>
<td>1.30</td>
<td>4.00</td>
</tr>
<tr>
<td>Science Summer Program/Internship</td>
<td>0.60</td>
<td>0.94</td>
<td>285</td>
<td>0.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Science Identity</td>
<td>3.12</td>
<td>0.55</td>
<td>298</td>
<td>1.80</td>
<td>4.00</td>
</tr>
<tr>
<td>Science self-efficacy</td>
<td>1.77</td>
<td>0.54</td>
<td>283</td>
<td>1.00</td>
<td>3.62</td>
</tr>
<tr>
<td>Centrality</td>
<td>4.94</td>
<td>1.08</td>
<td>295</td>
<td>1.62</td>
<td>7.00</td>
</tr>
<tr>
<td>Assimilation</td>
<td>4.86</td>
<td>0.79</td>
<td>283</td>
<td>2.56</td>
<td>7.00</td>
</tr>
<tr>
<td>Nationalist</td>
<td>4.11</td>
<td>0.88</td>
<td>294</td>
<td>1.67</td>
<td>7.00</td>
</tr>
<tr>
<td>Public Regard</td>
<td>3.46</td>
<td>1.03</td>
<td>293</td>
<td>1.00</td>
<td>6.17</td>
</tr>
</tbody>
</table>

**Qualitative Data Analysis.** The interviews were transcribed by a professional transcription company. The transcripts were reviewed for accuracy by replaying the audio recording of each interview. Participants were contacted via email to further explain any response that was either ambiguous or unintelligible. The transcripts were analyzed for common themes. The qualitative data was strongly analyzed through a Critical Race Theory lens, which exposes the effects of race, racism, and social inequity (Delgado & Stefancic, 2001). This theory provides a lens to properly evaluate and understand the perceptions and lived experiences of African American science students who attend HBCUs.

The qualitative data analysis process was highly cyclical and involved several stages
(Creswell, 2007). I began the process by sending the audio recordings of the interviews to a professional transcription company. The second stage involved listening to the interviews, while simultaneously reading the transcripts to ensure consistency between the two versions of the interview. Third the transcripts were edited by replacing all identifying names (i.e. participant names and institution names) with pseudonyms. A codebook consisting of *a priori* codes drawn from literature was developed in Microsoft Excel. The transcripts were printed, and I began the coding process by writing codes in the margins. Additionally, emerging themes were also written in the margin. After hand coding each of the transcripts, I uploaded the transcripts to Atlas.ti for a second iteration of coding.

Advances in technology have led to the introduction of computer-assisted qualitative data analysis software (CAQDAS). According to Cope (2014), CAQDAS are advantageous in qualitative research because they allow for greater efficiency and flexibility. Specifically, these programs make it easier to manage large transcripts, allows for ease in coding changes, memoing, and creating graphics of the data (Cope, 2014; St. John & Johnson, 2000). Significantly, the use of qualitative software allows researchers to focus more on determining the meaning and emerging themes, instead of manual tasks (Cope, 2014). According to St. John and Johnson (2000), using computer-based programs enables one to examine relationships or connections in data. The use of CAQDAS have the potential to enhance the rigor and validity of the research because they allow for all of the data connected to a single topic to be examined; thereby, contrasting the human proclivity to privilege certain parts that
are more aligned with one’s assumptions and worldviews (St. John & Johnson, 2000). The same codebook was established in Atlas.ti, and new emerging codes were added to the Atlas.ti codebook manager. The transcripts were analyzed before and after the results from the quantitative aspect were complete. Coding before I had the final results from the quantitative aspect allowed me to gain insight that specifically addressed research question four. However, coding the transcripts once I had the quantitative results allowed me to identify information that further explained or contrasted the quantitative findings.

I engaged in four cycles of doing the transcripts, as coding is not simply a process to label but to link critical pieces of data (Saldana, 2009). The frequency of various codes were analyzed and connected to create larger themes (Creswell, 2009). The codes, themes, and meanings from the qualitative were connected to existing literature, as well as to the literature review.

**Qualitative Data Trustworthiness and Credibility.** In order to establish credibility and trustworthiness of the qualitative data and my inferences, I employed the following validity procedures: member checking, thick description, and peer review (Creswell & Miller, 2000). Additionally, I engaged in a reflexive process to determine if the data were saturated to establish appropriate themes of categories (Creswell & Miller, 2000; Patton, 1980).

My own lens as the researcher was utilized in the process of establishing a credible qualitative data set. According to Patton (1980), when qualitative researchers repeatedly
return to their data to determine if the constructs, categories, explanations, and interpretations make sense, they are utilizing a reliable lens to establish credibility. Thus, I engaged in this prescribed reflexive process to ensure that appropriate themes were developed and that my interpretations made sense based on the shared experiences of the participants.

After analyzing the transcripts and writing my own interpretations, I engaged the students who participated in the interviews in a member checking process. Therefore, I asked the participants to assess the accuracy of how I represented their realities by reviewing their interview transcripts and related excerpts (Creswell & Miller, 2000). According to Lincoln and Guba (1985), member checking is one of the most vital techniques in establishing trustworthiness and credibility. The participants were sent the transcripts and interpretations and asked to provide feedback on their accuracy. The participants were asked if the themes make sense and if the overall account is accurate. The participants indicated that the interpretations and themes were representative of their experiences in science, in particular at their HBCU. As an additional lens to determine credibility, I enlisted the assistance of an individual external to my committee to review how I coded and interpreted the various student accounts. This external reviewer evaluated and coded one of the interview transcripts. Subsequently, we compared her codes to how I coded the interview to determine the interrater reliability. Last, she evaluated how I interpreted the interviews/codes and provided feedback.

Last, thick and rich descriptions of the students’ account were used to establish
credibility. According to Creswell & Miller (2000), such descriptions provide a portal through which the reader is able to enter into the account and feel like they have personally experienced the events described in the study. In developing thick, rich descriptions, I sought to provide as much detail as possible without overwhelming those who read this manuscript. For example, in included quotes from participants that vividly paint the picture of their lived experiences, I positioned the students in specific situations, provided details of how the participants felt in certain accounts, and highlighted relationships or interactions with two or more people (Creswell & Miller, 2000).

**Data Integration**

According to Creswell and Plano-Clark (2011), the integration of quantitative and qualitative data can substantially augment the value of mixed methods research. It is important to consider that a mixed methods design involves more that simply integrating quantitative and qualitative data sets, but it includes the integration of research worldviews/paradigms (Creswell & Plano-Clark 2007; Plano-Clark and Wang, 2010). In the case of this study, I intentionally integrated critical race theory into both aspects of this study in an attempt to empower the participants and promote the transformation of oppressive educational systems into more equitable ones (Ponterotto, Mathew, and Raughley, 2013). Thus, CRT was used as an analytic lens to identify quantitative data points that bring attention to disparities in power, the permanence of racism, and challenge dominant ideologies. Furthermore, through this critical worldview relevant lived experiences of the
participants were used to further explain the quantitative data. Quantitative and qualitative findings that revealed how the permanence of racism connects to each of the substantive theories were an integral part of the integration process.

There are different approaches to integrate quantitative and qualitative research procedures and data, which can be implemented at the design, methods, and interpretation levels of a study (Fetters, Curry, & Creswell, 2013). Integration at the design level is usually made possible through three basic designs: exploratory sequential, explanatory sequential, and convergent (Fetters, Curry, & Creswell, 2013). With regards to the sequential designs, the goal is to use the data from one phase to build or inform another. However, with a convergent design, the objective is to merge both phases so that the two data sets can be compared (Fetters, Curry, & Creswell, 2013).

Integration at the methods level involves linking the data collection methodologies and analysis, which can be accomplished in the following ways: connecting, building, merging, and embedding (Fetters, Curry, & Creswell, 2013). Integration through connecting involves linking one data type with the other data type through sampling (Fetters, Curry, & Creswell, 2013). For example, the participants in the interview are drawn from the participants who responded to the survey component (Fetters, Curry, & Creswell, 2013). Integration through building involves using the results from one data collection procedure (i.e. semi-structured interviews) to inform the data collection approach for another procedure (i.e. items to include on a survey) (Fetters, Curry, & Creswell, 2013). Integration through
merging involves bringing the quantitative and qualitative data sets together in order to compare their results (Fetters, Curry, & Creswell, 2013). I utilized merging as a way to integrate my quantitative and qualitative results, as it was important for me to compare the results from both data sets in order to fully address my research questions. Integration through embedding involves linking data collection and analysis at different points (Fetters, Curry, & Creswell, 2013).

There are three approaches to integrating quantitative and qualitative data at the interpretation and reporting level of a study: integrating through narrative, integrating through data transformation, integrating through joint displays (Fetters, Curry, & Creswell, 2013). Typically, when researchers are integrating through narrative, they provide a description of the quantitative and qualitative data in a single or series of reports (Fetters, Curry, & Creswell, 2013). There are three ways to integrate the two data sets through narrative: weaving approach, contiguous approach, and staged approach (Fetters, Curry, & Creswell, 2013). For the purpose of this study, I utilized the weaving approach which involves bringing the two data sets together on a theme-by-theme basis. Additionally, I employed a triangulation protocol, which included listing the findings from the quantitative and qualitative components on the same page and identifying where the findings from each converged, provided complementary information, or contradicted each other (O’Cathain, Murphy, & Nicholl, 2010). With regards to the contiguous approach, findings are compiled into a single report; however, the quantitative findings are located in one section while the
qualitative findings are positioned in another (Fetters, Curry, & Creswell, 2013). Finally, the staged approach is used for multistage mixed methods designs; therefore, the results from each stage are reported separately (Fetters, Curry, & Creswell, 2013).

One key aspect to integrating quantitative and qualitative data is the degree to which the data “fits” or the coherence of the findings from both data sets (Fetters, Curry, & Creswell, 2013). When evaluating fit, one may be lead to three possible outcomes: confirmation, expansion, and discordance. Developing a convergence coding matrix as a component of a triangulation protocol assisted me with determining the degree of “fit” (Farmer, Elliott, Eyles, 2006; O’Cathain, Murphy, & Nicholl, 2010). The matrix (see Table 7) displays the findings emerging from the quantitative and qualitative components on a single page.

Table 7

Sample Display of Quantitative and Qualitative Findings Table

<table>
<thead>
<tr>
<th>Quantitative Findings</th>
<th>Qualitative Findings Initial Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Science Identity (M=3.12 out of 4)</td>
<td>Appreciation for Subject Matter</td>
</tr>
<tr>
<td>Low Science Self-Efficacy (M=1.77 out of 5)</td>
<td>Family History at HBCU</td>
</tr>
<tr>
<td>Moderate Centrality (M=4.94 out of 7)</td>
<td>Aspire to graduate school</td>
</tr>
<tr>
<td>Moderate Assimilation (M=4.86 out of 7)</td>
<td>Black Cohesiveness</td>
</tr>
</tbody>
</table>

Subsequently, I evaluated the table to determine points of agreement, partial agreement, no matches, and dissonance (Farmer, Elliott, Eyles, 2006; O’Cathain, Murphy, & Nicholl, 2010).
Nicholl, 2010). The degree of fit information was organized into a paired comparison table (see Table 4). This approach is actually the only triangulation technique to include silence, which is when a theme or finding emerges from one data set but not from another (O’Cathain, Murphy, & Nicholl, 2010). When the results from both data sets confirm one another, the outcome of the data integration is confirmation. There are several examples of confirmation that resulted from my data integration; therefore, giving the results greater credibility (Fetters, Curry, & Creswell, 2013). Expansion results from the divergence of the quantitative and qualitative data such that the researcher gains an expanded understanding of the phenomenon of interest (Fetters, Curry, & Creswell, 2013). For example, there are several results from my quantitative data that reveals the strength and direction of relationships between constructs, while my qualitative data speaks to the nature of those relationships. During data integration, I not only looked for aspects of the two data sets that were similar, but I also looks for inconsistencies, contradictions, or conflicts. Therefore, the outcome was discordance when the findings from the two data sets did not agree (Fetters, Curry, & Creswell, 2013). I addressed such occurrences by re-analyzing the data, seeking explanations from theory and discussing future research option (Fetters, Curry, & Creswell, 2013). Once all of the comparison were completed, a convergence matrix for each category (i.e. agreement, partial agreement, dissonance, and silence was constructed to organize the information.
Ethical Procedures

In order to conduct this study, approval was initially obtained from North Carolina State University IRB. Subsequently, IRB was obtained from each of the five institutions in which the participants were recruited for both the quantitative and qualitative aspects of the study. I anonymized the study by assigning each participant a pseudonym after they completed the interview. I protected the data by storing it in an online drive that requires a two-step verification to access the files.

Summary

This chapter outlined the methodology for this study. It describes the details of the study design, provided a rationale for using a mixed methods approach, and discussed the research questions and hypotheses. Moreover, the chapter discussed data collection, data analysis, and data integration. Last, it provided insight into the ethical steps that were followed to ensure the overall protection and safety of each participant.
CHAPTER IV: FINDINGS AND DISCUSSION

Historically Black colleges and universities (HBCUs) produce a disproportionately high number of minority graduates in STEM majors despite the majority of African American college students being enrolled at predominantly White institutions (PWIs). The disparity in the number of African American STEM graduates from HBCUs and PWIs may indicate a problem within institutions related to educating African American science majors. The purpose of the current, mixed method study was to enhance understanding of the connections between science identity, racial identity, and science self-efficacy beliefs among African American students at HBCUs in the southeastern region of the United States. Within the study, I explored how these constructs influence science achievement at the institution, as well as the influence of pre-college experiences. Additionally, I endeavored to provide a detailed description of how African American students’ perspectives of their experiences at HBCUs influence their science self-efficacy beliefs, science identity, and racial identity.

I will present the quantitative and qualitative data separately, as well as merged in this chapter. Throughout the data analysis and interpretation, I take the central tenets of CRT and apply them where applicable. I will illuminate the findings from the study through the counternarratives of the interview participants. I have attempted to engage the participants in a “critical dialogue” that stems from the findings from the interviews, surveys, and existing literature (Solórzano & Yosso, 2002).
Quantitative Analyses for Research Question One

The quantitative data presented in this section will address the following research question: *What is the relationship between the science self-efficacy beliefs, science identity, and racial identity of African American students attending HBCUs?* The section will begin with a presentation of preliminary Pearson correlation analyses (See Table 10) followed by findings from moderation analyses.

**Science identity and racial identity.** A Pearson correlation analysis was conducted among Science Identity, Centrality, Assimilation, Nationalist, and Public Regard. I hypothesized that there will be a positive correlation between the racial identity of African American students attending an HBCU and their science identity. Cohen's standard was used to evaluate the strength of the relationships, where coefficients between .10 and .29 represent a small effect size, coefficients between .30 and .49 represent a moderate effect size, and coefficients above .50 indicate a large effect size (Cohen, 1988).

There was a significant positive correlation between Science Identity and Assimilation \( r = 0.17, \ p = .005 \). The correlation coefficient between Science Identity and Assimilation was 0.17 indicating a small effect size. This indicates that as Science Identity increases, Assimilation tends to increase. There was a significant positive correlation between Centrality and Nationalist \( r = 0.57, \ p < .001 \). The correlation coefficient between Centrality and Nationalist was 0.54 indicating a large effect size. This indicates that as Centrality increases, Nationalist tends to increase. There was a significant negative
correlation between Centrality and Public Regard ($r = -0.30, p < .001$). The correlation coefficient between Centrality and Public Regard was -0.30 indicating a moderate effect size. This indicates that as Centrality increases, Public Regard tends to decrease. There was a significant positive correlation between Assimilation and Public Regard ($r = 0.20, p = .002$). The correlation coefficient between Assimilation and Public Regard was 0.20 indicating a small effect size. This indicates that as Assimilation increases, Public Regard tends to increase. There was a significant negative correlation between Nationalist and Public Regard ($r = -0.17, p = .014$). The correlation coefficient between Nationalist and Public Regard was -0.17 indicating a small effect size. This indicates that as Nationalist increases, Public Regard tends to decrease.

Science self-efficacy and racial identity. A Pearson correlation analysis was conducted among Science self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard. No statistically significant correlations were revealed between science self-efficacy and the four dimensions of racial identity explored in this investigation. A preliminary regression analysis was conducted to assess if Centrality is a significant predictor of Science self-efficacy. The regression with Science self-efficacy predicting Centrality was conducted. The regression of Centrality on Science self-efficacy was significant, $F(2, 237) = 4.61, p = .033$. The results showed that Science self-efficacy was a significant predictor of Centrality, $B = -0.28$ (See Table 8). Additionally, a preliminary regression analysis was conducted to determine if Science self-efficacy predicts Public Regard. The regression of Public Regard
on Science self-efficacy was significant, \(F(2, 237) = 4.53, p = .034\). The results (see Table 9) showed that Science self-efficacy was a significant predictor of Public Regard, \(B = 0.26\).

Table 8

*Regression Results with Centrality and Science self-efficacy*

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Independent</th>
<th>B</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrality</td>
<td>Science self-efficacy</td>
<td>-0.28</td>
<td>0.13</td>
<td>-2.15</td>
<td>.033</td>
</tr>
</tbody>
</table>

Table 9

*Regression Results with Public Regard Mediating the Relationship Between College Science GPA and Science self-efficacy*

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Independent</th>
<th>B</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Regard</td>
<td>Science self-efficacy</td>
<td>0.26</td>
<td>0.12</td>
<td>2.13</td>
<td>.034</td>
</tr>
</tbody>
</table>

**Science Self-efficacy and Science Identity.** A Pearson correlation analysis was conducted among science self-efficacy and science identity. There was a significant negative correlation between Science Identity and Science Self-efficacy \((r = -0.30, p < .001)\). The correlation coefficient between Science Identity and Science Self-efficacy was -0.30 indicating a moderate effect size. This indicates that as Science Identity increases, Science Self-efficacy tends to decrease.
Table 10

*Pearson Correlation Matrix among Science Identity, Science Self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard*

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Science Identity</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Science Self-efficacy</td>
<td>-0.30*</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Centrality</td>
<td>0.09</td>
<td>-0.07</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Assimilation</td>
<td>0.16*</td>
<td>-0.10</td>
<td>-0.04</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Nationalist</td>
<td>-0.01</td>
<td>0.05</td>
<td>0.57*</td>
<td>-0.14*</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6. Public Regard</td>
<td>0.07</td>
<td>0.06</td>
<td>-0.30*</td>
<td>0.15*</td>
<td>-0.17*</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note.* The critical values are 0.13, 0.18, and 0.22 for significance levels .05, .01, and .001 respectively.

**Moderation Analyses.** I conducted moderation analyses to assess the research question: *What is the relationship between the science self-efficacy beliefs, science identity, and racial identity of African American students attending HBCUs?* I conducted a series of four sets of moderation analyses to address the following hypothesis: *The racial identity of African American students attending HBCUs will moderate the association between science identity and their science self-efficacy beliefs.* One moderation analysis was conducted per subscale of the MIBI (i.e., Centrality, Assimilation, Nationalist, Public Regard).

Moderation analysis was conducted to assess if Centrality moderated the relationship between Science Identity and Science self-efficacy. In the first step, a simple effects model was created using linear regression with Science self-efficacy as the outcome variable and Science Identity as the predictor variable. In the second step, a non-interaction model was
created by adding Centrality to the predictor in the linear model in step 1 (simple effects model). In the third step, an interaction model was created by adding the interaction between Science Identity and Centrality to the predictors in the linear model in step 2 (non-interaction model). Prior to the third step (interaction model), Science Identity and Centrality were mean centered to prevent multicollinearity in the linear model.

The assumption of normality was examined by creating a Q-Q scatterplot of the model residuals against the theoretical quantiles (DeCarlo, 1997). The residual quantiles must not strongly deviate from the theoretical quantiles. Strong deviations indicate unreliable parameter estimates and indicate that the assumption is violated. There were no strong deviations therefore the assumption was met. The assumption of homoscedasticity was assessed by examining plots of the interaction residuals against the predicted model values (Osborne & Walters, 2002). For the assumption to be met there should be no curvature in the plot and the points should be distributed about the mean of zero. There was no curvature in the plot and the points appeared randomly distributed therefore the assumption was met.

In order for moderation to be supported, two conditions must be met (Netemeyer et al., 2001). First, the causal predictor variable, Science Identity, must significantly predict Science self-efficacy in the simple effects model (step 1). Secondly, the interaction model (step 3) must explain significantly more variance of Science self-efficacy than the non-interaction model (step 2). If either of these conditions fail, moderation was not supported. Science Identity significantly predicted Science self-efficacy, $B = -0.41, t(268) = -7.51, p <$
Therefore, the first condition was met, and the second condition was checked. A partial $F$-test was conducted to determine if the interaction model explained more variance than the non-interaction model. The partial $F$-test, $F(1,266) = 1.26, p = .262$, indicated that the interaction model did not explain significantly more variance than the non-interaction model. Therefore, the second condition was not met, and moderation was not supported.

Moderation analyses were conducted to assess if Assimilation, Nationalist, and Public Regard moderated the relationship between Science Identity and Science self-efficacy; however, the results from each one indicated that moderation was not supported. The results from the Assimilation partial $F$-test, $F(1,258) = 2.10, p = .148$, indicated that the interaction model did not explain significantly more variance than the non-interaction model. The results from the Nationalist partial $F$-test, $F(1,267) = 0.02, p = .897$, indicated that the interaction model did not explain significantly more variance than the non-interaction model. The results from the Public Regard partial $F$-test, $F(1,264) = 0.40, p = .527$, indicated that the interaction model did not explain significantly more variance than the non-interaction model. Therefore, the second condition was not met for any of the three racial dimensions, thus moderation was not supported.

**Quantitative Findings for Research Question Two**

I conducted moderation and mediation analyses to assess the research question: *To what extent does science identity, science self-efficacy, and racial identity influence the science achievement of African American students attending HBCUs?* I conducted a series
of four sets of moderation analyses to address the following hypothesis: *The racial identity of African American students attending HBCUs will moderate the association between science self-efficacy beliefs and their science achievement.* I conducted one moderation analysis per subscale of the MIBI (i.e., Centrality, Assimilation, Nationalist, Public Regard). The mediation analysis was conducted to explore the following hypothesis: *The science identity of African American students at HBCUs will mediate the effect of science self-efficacy on their college achievement.*

**Centrality moderating the relationships between science self-efficacy and College Achievement.** Moderation analysis was conducted to assess if Centrality moderated the relationship between Science self-efficacy and College Achievement. As previously stated, in order for moderation to be supported, two conditions must be met (Netemeyer et al., 2001). Science self-efficacy significantly predicted College achievement, $B = -0.26$, $t(238) = -4.80$, $p < .001$. Therefore, the first condition was met, and the second condition was checked. A partial $F$-test was conducted to determine if the interaction model explained more variance than the non-interaction model. The partial $F$-test, $F(1,236) = 1.49$, $p = .223$, indicated that the interaction model did not explain significantly more variance than the non-interaction model. Therefore, the second condition was not met, and moderation was not supported.

**Assimilation moderating the relationships between science self-efficacy and College Achievement.** Moderation analysis was conducted to assess if Assimilation moderated the relationship between Science self-efficacy and College achievement. A partial
$F$-test was conducted to determine if the interaction model explained more variance than the non-interaction model. The partial $F$-test, $F(1,227) = 0.62, p = .433$, indicated that the interaction model did not explain significantly more variance than the non-interaction model. Therefore, the second condition was not met, and moderation was not supported.

**Public regard moderating the relationships between science self-efficacy and College Achievement.** Moderation analysis was conducted to assess if Public regard moderated the relationship between Science self-efficacy and College achievement. A partial $F$-test was conducted to determine if the interaction model explained more variance than the non-interaction model. The partial $F$-test, $F(1,235) = 0.47, p = .493$, indicated that the interaction model did not explain significantly more variance than the non-interaction model. Therefore, the second condition was not met, and moderation was not supported.

**Nationalist moderating the relationships between science self-efficacy and College Achievement.** Moderation analysis was conducted to assess if Nationalist moderated the relationship between Science self-efficacy and College achievement. Science self-efficacy significantly predicted College achievement, $B = -0.26, t(238) = -4.79, p < .001$. Therefore, the first condition was met, and the second condition was checked. A partial $F$-test was conducted to determine if the interaction model explained more variance than the non-interaction model. The partial $F$-test, $F(1,236) = 6.39, p = .012$, indicated that the interaction model explained significantly more variance compared to the non-interaction model. Therefore, the second condition was met. Since Science self-efficacy significantly
predicted College achievement in the simple effects model (condition 1) and the interaction model explained significantly more variance of College achievement than the non-interaction model (condition 2), then moderation was supported. Table 11 shows the results comparing the non-interaction and interaction models. Nationalist significantly moderated the effect Science self-efficacy had on College achievement, $B = 0.16$, $t(236) = 2.53$, $p = .012$. This indicates that on average, a one-unit increase of Nationalist will cause a 0.16 increase in the slope of College achievement on Science self-efficacy. The results of the simple, non-interaction, and interaction models are presented in Table 12.

Table 11

*Linear Model Comparison Table between the Non-Interaction and Interaction Model*

<table>
<thead>
<tr>
<th>Model</th>
<th>$F$</th>
<th>$df$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Interaction</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>0.12</td>
<td>6.39</td>
<td>.012</td>
</tr>
</tbody>
</table>
Table 12

*Moderation Analysis Table with College Achievement Predicted by Science self-efficacy Moderated by Nationalist*

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>t</th>
<th>p</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: Simple Effects Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>3.51</td>
<td>0.10</td>
<td>35.68</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>Science self-efficacy</td>
<td>-0.26</td>
<td>0.05</td>
<td>-4.79</td>
<td>&lt; .001</td>
<td>-0.30</td>
</tr>
<tr>
<td>Step 2: Non-Interaction Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>3.74</td>
<td>0.18</td>
<td>21.10</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>Science self-efficacy</td>
<td>-0.26</td>
<td>0.05</td>
<td>-4.73</td>
<td>&lt; .001</td>
<td>-0.29</td>
</tr>
<tr>
<td>Nationalist</td>
<td>-0.06</td>
<td>0.04</td>
<td>-1.53</td>
<td>.128</td>
<td>-0.09</td>
</tr>
<tr>
<td>Step 3: Interaction Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td>3.06</td>
<td>0.03</td>
<td>95.15</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>Science self-efficacy</td>
<td>-0.27</td>
<td>0.05</td>
<td>-5.03</td>
<td>&lt; .001</td>
<td>-0.31</td>
</tr>
<tr>
<td>Nationalist</td>
<td>-0.05</td>
<td>0.04</td>
<td>-1.45</td>
<td>.149</td>
<td>-0.09</td>
</tr>
<tr>
<td>Science self-efficacy:Nationalist</td>
<td>0.16</td>
<td>0.06</td>
<td>2.53</td>
<td>.012</td>
<td>0.16</td>
</tr>
</tbody>
</table>

**H₂: The science identity of African American students at HBCUs will mediate the effect of science self-efficacy on their college science achievement.**

A mediation analysis, as recommended by Baron and Kenny (1986), was conducted to assess if Science identity mediated the relationship between Science self-efficacy and College achievement. To determine whether a mediating relationship was supported by the
data, three regressions were conducted. For mediation to be supported, four items must be met: 1) the independent variable must be related to the dependent variable, 2) the independent variable must be related to the mediator variable, 3) the mediator must be related to the dependent variable while in the presence of the independent variable, and 4) the independent variable should no longer be a significant predictor of the dependent variable in the presence of the mediator variable (Baron & Kenny, 1986). In this analysis, the independent variable was Science self-efficacy, the mediator was Science identity and the dependent variable was College achievement.

First, the regression with Science self-efficacy predicting College achievement was conducted. The regression of College achievement on Science self-efficacy was significant, $F(2, 239) = 23.19, p < .001$. The results showed that Science self-efficacy was a significant predictor of College achievement, $B = -0.26$, indicating that the first criterion for mediation was satisfied. Second, the regression with Science self-efficacy predicting Science identity was conducted. The regression of Science identity on Science self-efficacy was significant, $F(2, 239) = 20.72, p < .001$. The results showed that Science self-efficacy was a significant predictor of Science identity, $B = -0.28$, indicating that the second criterion for mediation was satisfied. Next, the regression with Science self-efficacy and Science identity predicting College achievement was conducted. The regression of College achievement on Science self-efficacy and Science identity was significant, $F(3, 238) = 11.92, p < .001$ suggesting that Science self-efficacy and Science identity accounted for a significant amount of variance in
College achievement. The individual predictors were examined further. The results showed that Science identity was not a significant predictor of College achievement when Science self-efficacy was included in the model, $B = 0.05$, indicating that the third criterion for mediation was not satisfied. The results showed that Science self-efficacy was a significant predictor of College achievement when Science identity was included in the model, $B = -0.25$, indicating that the fourth criterion for mediation was not satisfied. Since item 3 and item 4 were not met, mediation cannot be supported. Table 13 presents the results of the mediation analysis.

Table 13

*Regression Results with Science identity Mediating the Relationship Between College achievement and Science self-efficacy*

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Independent</th>
<th>$B$</th>
<th>$SE$</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression 1:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College achievement</td>
<td>Science self-efficacy</td>
<td>-0.26</td>
<td>0.05</td>
<td>-4.82</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Regression 2:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science identity</td>
<td>Science self-efficacy</td>
<td>-0.28</td>
<td>0.06</td>
<td>-4.55</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Regression 3:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College achievement</td>
<td>Science self-efficacy</td>
<td>-0.25</td>
<td>0.06</td>
<td>-4.38</td>
<td>&lt; .001</td>
</tr>
<tr>
<td></td>
<td>Science identity</td>
<td>0.05</td>
<td>0.06</td>
<td>0.82</td>
<td>.411</td>
</tr>
</tbody>
</table>
Quantitative Findings to Address Research Question Three

I conducted moderation analyses and Pearson correlation analyses to assess the research question: *To what extent do the pre-college experiences of African American students attending HBCUs influence their science self-efficacy beliefs, science identity, racial identity, and college science achievement?* I conducted a series of four sets of moderation analyses to address the following hypothesis: *The pre-college experiences of African American students attending HBCUs will moderate the effects of their science identity on college science achievement.* I conducted one moderation analysis per subscale of the MIBI (i.e., Centrality, Assimilation, Nationalist, Public Regard).

**Science courses in high school, science identity, and college science GPA.**

Moderation analysis was conducted to assess if Number of science courses in high school moderated the relationship between Science Identity and College Science GPA. Science Identity did not significantly predict College Science GPA, $B = -0.06$, $t(248) = -0.82$, $p = .413$. Since Science Identity was not a significant predictor in the simple effects model, the first condition was not met. Therefore, moderation was not supported.

**Number of math courses in high school, science identity, and college science GPA.**

Moderation analysis was conducted to assess if number of math courses in high school moderated the relationship between Science Identity and College Science GPA. Science Identity did not significantly predict College Science GPA $B = -0.06$, $t(251) = -0.80$, $p = .426$. Since Science Identity was not a significant predictor in the simple effects model,
the first condition was not met. Therefore, moderation was not supported.

**High school GPA, science identity, and college science GPA.** Moderation analysis was conducted to assess if high school GPA moderated the relationship between Science Identity and College Science GPA. Science Identity did not significantly predict College Science GPA, $B = -0.05$, $t(247) = -0.78$, $p = .436$. Since Science Identity was not a significant predictor in the simple effects model, the first condition was not met. Therefore, moderation was not supported.

**Pre-college experiences, college science GPA, science identity, science self-efficacy, and racial identity.** A Pearson correlation analysis was conducted among high school GPA, Science courses in college, College Science GPA, Science Identity, Science Self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard (See Table 14). Cohen's standard was used to evaluate the strength of the relationships (Cohen, 1988).

There was a significant negative correlation between high school GPA and Science Identity ($r = -0.14$, $p = .047$). The correlation coefficient between high school GPA and Science Identity was -0.14 indicating a small effect size. There was a significant negative correlation between high school GPA and Assimilation ($r = -0.15$, $p = .031$). The correlation coefficient between high school GPA and Assimilation was -0.15 indicating a small effect size. There was a significant negative correlation between high school GPA and Public Regard ($r = -0.19$, $p = .005$). The correlation coefficient between high school GPA and Public Regard was -0.19 indicating a small effect size.
There was a significant positive correlation between Science courses in college and Centrality ($r = 0.15$, $p = .031$). The correlation coefficient between Science courses in college and Centrality was 0.15 indicating a small effect size. There was a significant negative correlation between Science courses in college and Assimilation ($r = -0.15$, $p = .031$). The correlation coefficient between Science courses in college and Assimilation was -0.15 indicating a small effect size. There was a significant negative correlation between Science courses in college and Public Regard ($r = -0.27$, $p < .001$). The correlation coefficient between Science courses in college and Public Regard was -0.27 indicating a small effect size.

Table 14

*Correlations for High School GPA, College Science Courses, College Science GPA, Science Identity, Science Self-efficacy, Centrality, Assimilation, Nationalist, and Public Regard*

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High School GPA</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. College Science Courses</td>
<td>0.08</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. College Science GPA</td>
<td>0.03</td>
<td>0.09</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Science Identity</td>
<td>-0.14*</td>
<td>-0.01</td>
<td>-0.11</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Science Self-efficacy</td>
<td>0.02</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.30*</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Centrality</td>
<td>0.10</td>
<td>0.15*</td>
<td>-0.08</td>
<td>0.09</td>
<td>-0.07</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Assimilation</td>
<td>-0.15*</td>
<td>-0.15*</td>
<td>-0.00</td>
<td>0.16*</td>
<td>-0.10</td>
<td>-0.04</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Nationalist</td>
<td>-0.05</td>
<td>0.11</td>
<td>-0.09</td>
<td>-0.01</td>
<td>0.05</td>
<td>0.57*</td>
<td>-0.14*</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>9. Public Regard</td>
<td>-0.19*</td>
<td>-0.27*</td>
<td>0.03</td>
<td>0.07</td>
<td>0.06</td>
<td>-0.30*</td>
<td>0.15*</td>
<td>-0.17*</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note:* The critical values are 0.13, 0.18, and 0.22 for significance levels .05, .01, and .001 respectively.
Qualitative Findings: Research Question Four

I engaged in thorough analysis of the interview transcripts in order to address research question four: *What is the role of the HBCU context in supporting/affirming/facilitating the development of racial identity, science identity and science self-efficacy beliefs?* There are several themes that emerged from this process to specifically answer this question. Each quote was selected based on its direct connection to, and highlighting of the emerging theme. Within the collective experiences of the participants, there are a total of three meta-themes with accompanying sub-themes (see Table 15). Those themes were: *Establishing Community Cohesion*, and *Building Science Capital*.

Table 15

**Meta-themes, Sub- Themes, and CRT Connection**

<table>
<thead>
<tr>
<th>Meta-Themes</th>
<th>Establishing Community Cohesion</th>
<th>Building Science Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Themes</td>
<td>(1) Black Racial Cohesion - <em>Spectrum of Blackness</em> - <em>The Struggle is Real</em> - <em>Racial Socialization</em></td>
<td>(1) Scientific Cultural Capital</td>
</tr>
<tr>
<td></td>
<td>(2) Black Science Cohesion - <em>We all go up together</em> - <em>Sense of Belonging</em></td>
<td>(2) Influence science-related behaviors and providing opportunities for practice</td>
</tr>
<tr>
<td>CRT Connections</td>
<td>(1) Permanence of Racism</td>
<td>(1) Challenge Dominant Ideology</td>
</tr>
<tr>
<td></td>
<td>(2) Challenge Dominant Ideology</td>
<td>(2) Whiteness as Property</td>
</tr>
<tr>
<td></td>
<td>(3) Whiteness as Property</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4) Voice of the people</td>
<td></td>
</tr>
</tbody>
</table>
Establishing Community Cohesion. The meta-theme of *Establishing Community Cohesion* may be described as the extent to which connections are perceived between various elements of the campus environment/community that are relevant to the students’ identity development. It is centered on individuals from different backgrounds sticking together due to a common vision and strong sense of belonging. In this case, the difference in background is related to the different areas of the country that the students grew up in prior to their collegiate matriculation. Moreover, the differences within the group are strongly related to the subtheme of a *Spectrum of Blackness* that is present at each institution. Furthermore, the common vision amongst the group is the high degree of success, excellence, and defying racial barriers. Ultimately, the HBCU environment fosters a strong sense of belonging within the campus community, Black community, and science community. With that said, there are two major sub-themes associated with Community Cohesion that fosters the development of students’ racial identity and science identity: *Black Racial Cohesion* and *Black Science Cohesion*. Based on accounts from the students, there are key aspects each HBCU that establishes cohesiveness with who they are as members of the African American community and Science community. In this section, I will explain Black Racial Cohesion and Science Cohesion, as well as provide quotes to reveal how they are established across each of the HBCUs attended by the participating students.

*Black Racial Cohesion*. According to Bentley-Edwards (2016), racial cohesion is “how racial identity, behaviors, relationships, interests, and/or agency regarding one’s own
racial group coalesce” (p.76). Additionally, the extent of an individual’s racial cohesion influences how the individual perceives and engages with other Blacks, or Black spaces. Moreover, Black racial cohesion entails “a specific race-based connection that may represent a distal emotional connection with the global Black community as well as a proximal, behavior-based bond to Black spaces” (Bentley-Edwards, 2016, p.76). While racial cohesion is not the same as racial identity, it does serve as an indicator of how closely attached a person has become to the African American community. There are features of the various institutions that fosters a closer connection with one’s Black racial identity that in turn results in aligning one’s behaviors, relationships, and sense of agency with the Black community.

One characteristic of social cohesion involves a collision between community involvement and a strong sense of belonging within a given environment, but this construct is devoid of considering the role of one’s culture (Bentley-Edwards, 2016). Conversely, Black racial cohesion takes into consideration the cultural history (i.e. struggles and successes) of African Americans. Each of the students within this study expressed the strong sense of belonging that they experience on their campus that not only shapes their racial identity, but provokes them to use their skills and talents to help advance the Black community. For instance, Mary, a junior chemistry student at North Central M&T, reported feeling very comfortable within her HBCU environment, which allows her to focus on the unique aspects of members of her racial group without the negative connotations. Mary’s expression of comfort within the confines of her HBCU alluded to an attenuation of comfort beyond its
boundaries; thereby, subliminally shedding light on the racialized structure of our society. To elaborate, there is a subordination that accompanies her blackness in mainstream society which is aligned with the CRT notion of the permanence racism in America.

Being an African American student at an HBCU, it feels like you’re just like everyone else. Of course we have our unique characteristics and that’s something that you see all the time, but I think that being African American at an HBCU, it provides that sense of comfort.

Mary’s comment revealed the development of her Black identity, in a way that is aligned with social identity theory; therefore, being surrounded by members of her racial group within the HBCU context helps her to better identify with her Blackness. According to Bell (2004), the idea of whiteness has an oppressive effect on blacks; however, Mary’s comment revealed that this is somewhat buffered within the HBCU environment. The “sense of comfort” lends to an acceptance within the Black community, but highlights the CRT property function of whiteness known as “the absolute right to exclude” (Harris, 1993). The right to exclude is usually manifested when African American students enter predominantly white educational settings in the “role of an intruder who have been granted special permission to be there” (Ladson-Billings and Tate, 2006, p. 23); however, within the HBCU context they do not feel like an intruder but a non-interloper who does not need permission to obtain a quality education. The impact of the absolute right to exclude is typically experienced when these science students enter into science-related spaces beyond the
boundaries of their HBCU. LaDonna, a sophomore pharmaceutical sciences student at Calvin University, confirmed that she felt like she belonged at her HBCU and within the African American community, as she has learned more about her culture. She has begun to connect with the norm of her environment, the presence of African Americans, which has allowed her to connect more with the African American community.

It’s a great experience. I will definitely say that every Black student should experience an HBCU because a lot of our culture is missed but you notice is and it really is a culture, and it’s an environment of everybody. You’re just around like you never know where people are coming from, who they really are. If you sit down and talk to them.

LaDonna’s comment as well the comments from other students resulted in the emergence of the sub-theme of a *Spectrum of Blackness* serving as a facilitator of black racial identity development; therefore, stimulating a greater cohesiveness with the African American community. Hannah, a senior physics student at North Central M&T State University, spoke of how the spectrum of Black has shaped how she sees herself as an African American, because she was not exposed to it in her predominantly White high school.

I feel like there are definite...I think even with M&T there are different sections of, I guess, blackness. Being able to see that different spectrum has
definitely helped me a lot. Especially coming from a predominantly White high school. It was kind of shocking when I first got here, but I think it definitely helped me be more comfortable.

I describe the spectrum of Blackness as the diversity of members from the African American and African communities that are present on the college campus. Shannon, a senior physics student at North Central M&T State University, expressed how her racial identity and behavioral manifestations (an aspect of racial cohesion) have been influenced by the wide array of African American and African people on her campus.

I’m okay with myself and different types of people, you have different types of Black people walking around campus all the time too. You have the regulars and then you have the art people. I hang out with the art people a lot. You have the hippy people who I hang out with too. I hang out with the ratchet people. It’s just a cool little mix. I’m all those things.

Like Shannon, Patricia, a junior biology student at Calvin University, finds that access to this spectrum of Blackness has allowed her to discover more about who she is as an African American. Again, the being able to socialize with the array of students have made their race more salient and integrated more into the core of their self-concept.

It’s very welcoming to me because since it is HBCU a majority of the students are African American or African. And so to me, I don’t feel
Odd...One thing that I do want to mention that a lot of people misconceive about HBCUs, we’re not all the same. So a lot of my friends that went to PWIs or other schools...They’re like I didn’t want to go to HBCU because I didn’t want to be surrounded by Black people, the same people all the time. But me going around campus, myself is so different from another girl that I see, personality wise, dress wise, it’s so different. And even the skin colors are different. So like me, we’re all “Black”, but I don’t feel like I’m around the same people all the time because everyone is so different.

When Destiny, a junior chemistry student at North Central M&T, was asked how she would describe her HBCU to another person she spoke of how comfortable she feels because of it being family-oriented. Her HBCU mirrors a feeling that she feels at home, and a character trait of the African American community. Moreover, she speaks of the socialization process that involves interactions across this Black spectrum

I would say very cultured and family-oriented, because every department is kind of their own family and I don’t know if it’s just because we have similar skin types or we just know the background and the culture of where people come from. But it’s more supporting and looking out for people, knowing that we all struggle and we all come from different backgrounds. We always learn, it’s always a
learning experience when we meet people from everywhere.

Likewise, Shannon speaks of how the reality of the “struggle” is a shared experience that fosters a stronger network amongst students who attends an HBCU.

To my other friends, like, when I tell them well we don’t get as much funding. We live barely right on the same street as [the PWI in the same city], and they have more things than us and that’s like why I go to this school because I like the struggle. I like the story of the struggle. Like yeah we don’t have much but we’re out over here where in my environmental science class he said we’re like the top seven percent out of the world….because we’re all struggling, we’re all trying to get it together to better our race and ensure our future.

The shared pursuit of higher education conflated with the shared struggle fortifies the students’ identification with their racial group. Both Tiffany (a sophomore biology student at Jackson B. Southerland) and Shannon use of the Black collective “we” serve as an indicator that they are both affirming their association with the African American community (O’Conner, 1997). Here in lies the CRT tenet of “voice”, in that, I “look to the bottom” (Matsuda, 1995) in an effort to highlight the value of the knowledge shared by these African American students (Dixson & Rouseau (2006). While their stories differ and there is not a common voice, there is a common experience of systemic racism (Dixson & Rouseau) that
produces a struggle by which their black cohesiveness is fortified. The amalgamation of the students’ comments about the struggle builds the sub-theme: *The Struggle is Real*. The students have an awareness of the past struggles of African Americans in the United States, which fosters a bond with one another and African American heritage. According to social identity theory, such internalization of the shared experience fosters the development of their racial identity, and viewing situations from the groups’ perspective (Stets & Burke, 2000). Their racial consciousness heightens as a result of their participation in a collective struggle. However, through socialization with other African Americans on their campus, they gain an even greater awareness of the present day struggles of African Americans as a result of a system that privileges the education of White Americans over African Americans; thereby, fostering an even tighter connection. These accounts which paint a picture of the present day reality of a historical African American struggle further affirms the CRT notion of the permanence of racism in American, specifically institutional racism.

The students’ in the interview expressed a strong sense of racial group identity, as well as an awareness of the systemic constraints that have impacted their institution and personal journeys. Sanders Thompson (1999) reported a significantly positive correlation between the rate of interaction with other African Americans, in the form of racial socialization and maintenance of relationships with other African Americans, and racial salience. In fact, many of the students interact with other students on their campus that have to work due to their social economic statuses and insufficient financial aid. Sadly, eight of
the fourteen interview participants worked and attended school full-time; thus, I refer to them as working-learners. Shannon asserts “I know everybody I talk to, we all go to work. So it's easy to talk to African Americans about that stuff.” When Omar, a sophomore chemistry student at Franklin State, is asked what it is like to be an African American in science, his overall reifies the CRT goal to challenge meritocracy (Ladson-Billings & Tate, 2006). Specifically, the fact that he has to work and matriculate through a rigorous chemistry curriculum puts him at a disadvantage compared to his White counterparts who do not have the same struggle. Nonetheless, he has been able to engage in research, work at a fast food restaurant in the mornings, and raise his GPA from a 3.2 to 3.4.

Well, I mean, I don't want to say it's not hard because it is, but especially with what I've been doing because I've and juggling jobs in between to help myself monetarily. Through that way is hard. If you're not doing anything like that, if you're not working jobs in between college, then I don't see the difficulty. I feel like anyone really can do it.

**Black Science Cohesion.** As a derivative of social and racial cohesion, I would like to introduce the concept of Black Science Cohesion. Like racial cohesion, Black Science Cohesion manifests when a collision takes place between one’s sense of belonging within the science community, community involvement, and cultural characteristics. It may be described as the blending of science identity, racial identity, behaviors, relationships, interests, and one’s sense of agency in using his/her position in science to benefit the African
American community. The social relations that students are able to engage in with African American faculty and peers results in the development of their science identity, as well as a greater cohesiveness with the science community. Within the HBCU context these interactions establish a greater cohesiveness with the Black science community.

The structural characteristics (i.e. small class size and accessibility to professors’ offices outside of class) of the institutions foster the establishment of Black science cohesion. The opportunity to interact closely with like-minded peers who are African Americans within intimate classroom settings motivates the students to continue to pursue their science degree. Again, the shared “struggle” within the science context with other African Americans established a motivational bond with other African American science people. To this end, the sub-theme *We all go up together* supports the larger Black Science Cohesion theme.

Culturally, students were able to discuss the realities of being an African American in science, both past and present. Through these interactions, the students established a shared responsibility for the science success of their peers; therefore, revealing the strengthening of their Black Science cohesion. The extent of their science cohesion, not only represented the development of their science identity facilitated in these collaborative spaces, but the significance that relationships with other African American science people have on their participation in science. For instance, when Tiffany was asked how interactions with her peers shaped her science identity she stated:
... We all kind of help each other out along the way. We all give each other different connections that we don't have. They help me, I help them, but at the same time we're going together. It helps a lot to know that I'm not in this alone. That we're all going together. One make it...We're all going to end up making it.

When Josiah, a senior physics student at North Central M&T, was asked about the role interactions with faculty and peers have played in shaping his science identity, he further explained the partnership that he and his peers have established related to the struggle in becoming an African American scientist. Moreover, his sense of agency of assisting other African Americans succeed in science is an indicator of high Black STEM cohesion.

Well they've helped me, faculty, they've helped me to understand what a scientist is. So that's also made my goal. And that's definitely one of the main ways you can shape something, by figuring out what you’re shaping. And then my peers help me to figure out well how can we all be successful to get to that point. The people who've been there, as in the graduate students, the people above me, they help guide and they help show me, okay this is the way to go, this is what not to do. The peers that I have on my level, this is how we're going to struggle together to become a scientist. And even the people who
are beneath me, I get to see that sometimes they have something to bring to the table that I may not have known just through my interactions and me talking to them. Because they might have had success, they can put me into communication with other people.

A strong sense of belonging in the science community is reflective of both one’s science identity and science cohesion. Each of the students expressed a fairly high degree of satisfaction with their science department, which invoked a strong sense of belonging within the science community. Like other students, Hannah’s satisfaction was also connected with the authentic research opportunities that her department exposed the students to in an effort to shape their identity. In return, this has established a stronger sense of belonging in the science community.

I feel like M&T does a good job, well at least in my department, does a good job in making sure we do research and that you're involved in every aspect of research. Not just show up and watch your PI do all the work. You're going to do the work, you're going to be here early and put in the time just like everybody else. I feel like that's a really good method and mindset to have in research.

Attending an HBCU has also provided the students with opportunities to become involved with science-related organizations, as well as take the science they have learned in
the classroom into the African American communities positioned near their institution. According to Carlone and Johnson (2007), the opportunity to be recognized as a scientist and perform science functions as key facilitators of science identity development. In alignment with the definition of racial cohesion (Bentley-Edwards, 2016), the students’ Black STEM cohesion is demonstrated through the bringing together of the students racial identity, sense of belonging within the science community, and involvement in both the Black and science communities. They can be recognized within the science-related clubs/organizations on their campuses and by other African Americans in the surrounding community. Patricia shared how such experiences have developed her science identity and influenced her interests in showing African American children that they too can succeed in science:

...we do like community service once in awhile and I remember last time we went to the boys and girls club and we did a science fair for the children and most of the people at the boys are girls club are African American or minorities. And I remember them being so amazed when we said we were scientists because we all looked like them and I'm sure they're not used to you know scientists that look just like them, and it’s like literally we go to school right down the street this could be you in like 10 years literally. So to me that meant a lot and it was nice because it’s like I know I'm different but there are also a lot of people who look just
like me and if I'm doing I can inspire the even other people around me don't want me to make it.

Mary recently became the president of the Chemistry Club at M&T, which was prompted by a strong desire to help other African American chemistry students succeed.

Last year is when I got heavily involved in the Chemistry Club. I was not a part of the executive board, but I decided last year really at the end of the year to run for president. Miss Latifah was leaving. She was my mentor at the time. I just felt that there were people in our department who needed to be reached and people outside of our department who needed to be reached by the Chemistry Club and what the organization could do. I think that we have grown our relationships, and we've become a lot closer as friends. We have a senior, two juniors and two sophomores, so there's that mentorship ladder where we're all ... Four out of the five of us work in the same lab, so we've gotten very close. I think it's really helped all of us.

These types of behaviors or involvement with both the chemistry department (due to her sense of belonging) and the surrounding community (sense of agency) are characteristic of how the various HBCUs promote Black STEM cohesion. Would the students capitalize on similar science-related clubs or be provided with opportunities to use their science knowledge within the African American community at PWIs? Moreover, four of the students
(i.e. Dennis, Mary, Josiah, and Hannah) are the presidents or vice president of the clubs for their disciplines, which fortified their science identity through recognition and their Black STEM cohesion. Would they have similar opportunities for leadership within the science communities at PWIs, or would barriers prevent access to the positions?

African American students within the HBCU context expressed a similar perceived unity, in that, they seek to disprove norms and dismantle negative stereotypes. The type of cohesiveness that White or Asian Americans experience with the science community lacks the need to combat racial stereotypes. The various student accounts further emphasized the CRT tenet of the permanence of racism that the students must face as aspiring scientists. Hannah spoke of how racial stereotypes influenced her science identity:

One thing for me is knowing that in a group of very few, especially physicist, it kind of defy the stereotype of black people don't do science. That's definitely something I enjoy. I love going in a room, saying I'm a physicist and people being shocked about it. Especially white people. It's amazing. For me, I enjoy it.

The overarching theme of Community Cohesion sheds light on how HBCUs not only affirm or facilitate the development of students’ racial and science identities, but how the characteristics of the environment also external expressions of racial and science enactment. Hence, the supporting themes of Black Racial Cohesion and Black Science Cohesion focus on the transition from identity development to identity enactments.
Building Science Capital. The theme of Building Science Capital stemmed from a thorough evaluation of several codes with high frequencies amongst the student sample. The concept of “science capital” was first introduced by the ASPIRES (2013) Young people’s science and career aspirations research project. The researchers conceptualized science capital as “science-related qualifications, understanding, knowledge (about science and ‘how it works’), interest and social contacts (e.g. knowing someone who works in a science related job)” (ASPIRES, 2013 p. 13). Moreover, Archer et. al (2012) reported that students’ science capital is greatly related to their science aspirations and identification with science. Science capital was derived from Bourdieu’s (1977) conceptualization of ‘capital’, which are the economic, cultural, and social resources that provide individuals (who possess such capital) with a social advantage within certain context. According to Archer et. al (2015), science capital includes scientific literacy, scientific dispositions, knowledge of the transferability of science knowledge, science-related behaviors and practices, and science-related social capital (i.e. social contacts and relationship). Within the shared experiences of the students, we gain greater insight into how the institutions support the development of their science identity by building their science capital. In alignment with the CRT quest to magnify the voices of African American people, I will provide quotes from the students to explain how the students perceive their HBCU support the development of their science identity by building their science capital.

Scientific Cultural Capital. The smaller theme of scientific cultural capital entails the
scientific dispositions (appreciation for subject matter), scientific literacy, and awareness of the transferability of scientific knowledge in the workforce. For each of the students, they all expressed a strong appreciation for the subject matter, which is indicative of their scientific disposition being established prior to the matriculation; however, many of their faculty members have created classroom atmospheres that have augmented their scientific disposition. For instance, Chris, a junior chemistry student at Franklin State, shared that his mentor, Dr. Chan, enhanced his already existing positive disposition towards chemistry through creating an engaging, motivating and challenging learning environment.

When I first got to Franklin State I was kind of wishy-washy on what STEM major that I wanted to be. First it was computer science and that kind of just got meddled up. Dr. Chan basically made me fall in love with chemistry, so that's how I got chemistry. He just made it fun to learn.

You have to be in the classroom to understand but he’s a great teacher.

With regards to scientific literacy, this concept includes the scientific knowledge, skills and understanding of the manner in which science works (King, Nomikou, Archer, & Regan, 2015). Additionally, it involves the students’ ability to employ and apply these abilities in their day-to-day activities and to benefit society (King, Nomikou, Archer, & Regan, 2015). Each of the institutions developed students’ science literacy by instituting a rigorous curriculum that presses students to acquire a solid understanding of scientific concepts. Moreover, the students are exposed to primary scientific literature, thus promoting
the type of scientific literacy that prepares them for a successful scientific journey. Mary, who entered the institution without awareness that she could possibly publish her own research in journals, expresses how her exposure has given her advantage over her peers who have not been introduced to scientific literature. Her exposure to scientific literature is mainly through her laboratories or on campus research experiences.

When I first got to M&T and when I was in high school, I really didn't even know that it was possible to get your name in a journal. Then of course writing lab reports you have to read these journals, but I just never thought that my name could be in there. It was something that really showed me that I can be more than what's out there, what's displayed to students who are my age or who are younger than myself.

With regards to transferability of science in the job market, the institutions intentionally increased the students’ awareness of other careers in which to utilize their science degrees. Moreover, they also introduced them to other African Americans who have been able to transfer their science qualifications into a variety of fields. The professors invest in the student’s science cultural capital by positioning them in atmospheres that illuminate the extrinsic value assigned to careers beyond being a doctor or a science teacher. Tiffany was exposed to new career options through her seminar course, which was intentional about bringing in speakers who were African American practitioners or researchers. Such deposits fortified both her science identity and science self-efficacy beliefs (through vicarious
I know seminar class they had two graduates, two alumni who had graduated here, they became ... I forgot what it was called, but they are foot doctors. Yeah. I have never heard of stuff like that before, so to have them bring them here it gives you another outlook on different fields you can go into.

Influence science-related behaviors and providing opportunities for practice.

Through the shared experiences of the students, it became evident that the various science departments go “above and beyond” with providing the students opportunities to practice science. Beyond the classroom, many of the students are actively involved in science-related clubs/organizations and encouraged by their faculty members to participate in authentic research experiences, internships and conferences. Dennis, a chemistry second-degree seeking student at Calvin University, shared the process that stimulated an even greater interest in chemistry and provided him with the capital to function as a research scientist or doctor. While he had a pre-existing appreciation for the subject matter, his PI/Chemistry Instructor built his science capital in the dimension of science related behaviors and practices.

Another reason was I really enjoyed my General Chemistry I course and my General Chemistry II course, and then after that General Chemistry I course
was over, she [PI/Instructor] asked me, "Hey, if you're ever interested in doing research, then my doors are always open." I actually came to her that spring semester, and I told her, "Hey, I wouldn't mind doing research with you." One of her research technicians was actually headed into medical school… She showed me the ropes of how to approach the MCAT, how much you needed to study and things such as that. I worked with her for about a semester before she matriculated into her school, and I picked up her research where she left off. That made me even more intrigued to pursue chemistry. Actually, that's when I actually decided to declare my major in chemistry, is when I started to actually do work in her research lab. …and I presented a poster on my current research at the NOBCChE Conference, National Black Chemist and Chemical Engineers Organization.

**Building a Network: Growing Science-Related Social Capital.** According to King et al. (2015), science-related forms of social capital includes the science knowledge and qualifications of family members, as well as knowing individuals who possess science-related occupations. Students like Destiny and Omar entered college with technically a higher portion of science capital than the other twelve participants, because they have siblings who obtained degrees in the same discipline as themselves. Moreover, their siblings attended the same HBCU, thus their relationships with faculty members resulted in an almost guaranteed relationship between these two and the faculty. Destiny stated:
Data Integration Findings

In order to gain a fuller and richer understanding of the quantitative findings, I integrated to two data sets using a weaving approach. Throughout the data analysis and interpretation, I take the central tenets of CRT and apply them where applicable. First, the degree of agreement between the two data sets was determined through the construction of a comparison table (see Table 16). From this analysis, several themes emerged to explain the relationships between the various constructs of interests within the context of HBCUs: *I Prefer Black Spaces, but I Strategically Assimilate, The Source Makes the Difference, and I’m Going to Handle My Business and Confidently Prove-Them-Wrong.*
Table 16

Sample Paired Comparison of Quantitative and Qualitative Findings

<table>
<thead>
<tr>
<th>Key Findings</th>
<th>Quantitative</th>
<th>Qualitative</th>
<th>Agreement, Partial Agreement, Dissonance, No Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Science Identity (M=3.12 out of 4)</td>
<td>++</td>
<td>+</td>
<td>Partial (Explanation)</td>
</tr>
<tr>
<td>Low Science Self-Efficacy (M=1.77 out of 5)</td>
<td>++</td>
<td>-</td>
<td>Dissonance</td>
</tr>
<tr>
<td>Moderate Centrality (M=4.94 out of 7)</td>
<td>++</td>
<td>++</td>
<td>Agreement (Confirmation)</td>
</tr>
<tr>
<td>Moderate Assimilation (M=4.86 out of 7)</td>
<td>++</td>
<td>+</td>
<td>Partial Agreement (Explanation)</td>
</tr>
<tr>
<td>Sig. + Correlation b/n Sci ID &amp; Assimilation</td>
<td>++</td>
<td>+</td>
<td>Partial (Explanation)</td>
</tr>
<tr>
<td>Sig. + Correlation b/n Centrality &amp; Nat’l</td>
<td>++</td>
<td></td>
<td>No Matching Data</td>
</tr>
</tbody>
</table>

Note: If the exact information related to a particular findings was identified within the data set, then a ++ was used as a symbol. If supporting/related information related to a particular finding was identified within the data set, then a + was used as a symbol. If contrasting information related to a finding was identified within a data set, then a - was used as a symbol. If no information was identified in the data set, then no symbol was placed in the block.

**Science identity and racial identity: I Prefer Black Spaces, but I Strategically Assimilate.** There was a significant positive correlation between Science Identity and Assimilation ($r = 0.17, p = .005$); therefore, science identity increases are accompanied by increases in the assimilationist ideology. The partial agreement between this quantitative finding and information from interview participants further elaborated the positive
correlation between science identity and assimilation; therefore, leading to the theme: *I Prefer Black Spaces, but I Strategically Assimilate.* One key finding from the semi-structured interviews that explains how the students’ science identity development is facilitated by HBCUs is the heavy emphasis placed on undergraduate research at the different HBCUs. Previous studies have reported undergraduates tend to identify more as scientists after engaging in scientific research (Robnett, Chemers, Zurbriggen, 2015). Many of the students expressed that their departments really push engaging in research, internships, shadowing experiences, and conferences; therefore, the students’ science identity is being informed by the social interactions that occur within these different “communities of practice” (Ashbacher, 2010). The students begin to construct their identities, in relation to these communities, as they cultivate their knowledge, competence, and meaning from the social interactions (Ashbacher, 2010). The science identity constructed within this situated learning framework influences how the students view themselves and how they perceive others view them as they engage in scientific endeavors (Ashbacher, 2010). As students participate in multiple social communities, they are required to negotiate their identities back and forth based on the rules and values established by these communities (Furman & Calabrese Barton, 2006).

While the students attend an institution which positions them amongst other science students and scientists who look like them, they all expressed throughout their interviews that science lacks diversity and is still very much dominated by White males. They allude to a critical awareness that a racialized hierarchy of society has resulted in designating the
domain of science as White property. So while there is an overrepresentation of African American/African scientists at their HBCU, there is a very obvious underrepresentation when they transition from their institution into conference, research, and medical settings. While the faculty members at many of the institutions attended by the students in this study are aware of the dominance of White males in science, they are very encouraging and supportive of the students’ pursuits of becoming research scientists or physicians. Moreover, they share with them both sides of the coin, in that, they prepare them for the unwelcoming response they may receive while simultaneously helping them to see the advantages of being African American in science. Dennis shared that his PI [an African American female] shared with him that he would have really good opportunities going into chemistry as a black male; however, she did so by making him critically aware of the asymmetrical representation of African Americans within chemistry.

I think she [his PI] made that statement simply because at the end of the day, you don’t really see many chemistry students, for one, at HBCUs in the first place. That same day, she told me the statistics of chemistry majors that they actually graduate a year, and she says there was less than 10 per year. She told me about the ACS [American Chemical Society] certification in the Chemistry department, and she said she hasn’t seen a black
person with an ACS in maybe two or three semesters. I would imagine they only graduate maybe one a year that’s actually ACS certified…I maybe know six African Americans that’s majoring in chemistry. The rest are White.

Dennis’ comment alludes to systemic racism, further affirming the CRT notion of the permanence of racism in American society, at both the secondary and postsecondary levels of educations that impedes access to the chemistry field for African American students. Moreover, they show that there are structural and systemic features in place that are working against African American students to protect and demarcate chemistry as white property.

When presented with the question of what it is like to be an African American in a science field, each students’ answer honed in on the Eurocentric characteristic of science and how it impacts them to not see other scientists who look like them when they step away from their institution to “do science”. Patricia, a junior biology major at Calvin University expressed “sometimes it’s a little awkward because most of the time when you look around there’s no one that looks like you. So, you have to quickly get over that.” As indicated by Dixson and Rousseau (2006), whenever “we accept the notion of whiteness as normal” (p. 41) then any person who is not white tends to be considered as abnormal. As science students, the participants are faced with the need to constantly negotiate the normality of whiteness and the abnormality of blackness in science. Patricia further shares that her academic background helps her to “get over it” therefore helping her to acclimate to a world
that is different from what she experiences at her HBCU and at home. The process of getting over it [the norm of whiteness and abnormality of blackness] involves not internalizing a shame in being African American:

And I’m thankful, even though my background was kind of hard sometimes, I’m thankful for it because I’m used to being around people who may not look like me, like my Catholic background specifically. Being around people who don’t look like me and may not like that I’m there but I’m able to overcome that and do what I need to do to be where I need to be. And so for a lot of other people who grew up in an HBCU environment their whole life, you know what I’m saying...It might be more difficult to adjust, just because you have to go through a time to overcome that period of people not liking you...people not supporting you because they feel like you’re not supposed to be there.

From a CRT perspective, such accounts revealed the permanence of racism (Bell, 1992) within predominantly white institutions and disciplines (i.e. science). Specifically, we see that the students have a heightened perception of science being White property. To this end, the underrepresentation of African Americans and racialized experiences impacted not only how they saw themselves as African Americans but as scientist who belong in the
When the students were asked to discuss what it would be like to be an African American scientists/science student at a PWI, they almost unanimously expressed that the environment would be unwelcoming to the point that it would attenuate their sense of belonging in the science field as a whole. Aniyah transferred from a PWI as a result of becoming pregnant with her daughter. She expressed “I felt like they didn’t accept me”, which matched the assumptions of other students who had not attended a PWI. LaDonna, a sophomore pharmaceutical sciences student at Calvin University, also transferred from a PWI. LaDonna expressed that she experienced either microaggressive comments or behaviors from both faculty and peers during her time at the institution:

“My first math instructor Dr. Kosmin...I walked into her classroom, and she went around asking everyone where they’re from. “Hey, where are you from?”... “Gillensboro, North Central,”””No, before that.” I was like, “I was born in Miami,” and she was like, “No, before that.” I was like, “Do you want me to jump on the mothership?” I dropped that class but that was it, and I just knew that that’s not how I wanted to be treated by my professor.”

The experiences shared by students who transferred from PWIs, as well as the perceptions of students related to what their experience would be like at a PWI are aligned with the
permanence of racism within predominantly White institution. Lacy (2004) contends that middle-class African Americans may maintain their connections to the black world not only as a refuge from racial discrimination, but also because they enjoy interacting with other black people. Many of the science students in this study expressed during their interview that they enjoy being around other black people, in particular those who have a similar mindset as their own, and it minimizes the likelihood of negative race-based experiences.

One of the most salient aspects about the various HBCUs was how well they position students to be able to attend and present their research at various conferences; therefore, catalyzing their transition across the boundary line that separates them from the predominantly White, male playing field of science. While the students’ participation in research often time leads them to predominantly white conferences to present their research, their preference is attending and participating in conferences that are more heavily saturated with African American scientists. Hannah shared that she presents her research at least twice a year at various conferences. Her experiences are drastically different based on whether the conference is predominantly black or predominantly white; however, she has learned how to strategically engage with white scientist within the science community.

At NSBP, National Society of Black Physicist conferences, I guess it’s more relaxing in a sense for me. To be in a space where it’s other physicists of color and I can enjoy it more in a sense because we have this
understanding whereas other conferences like SPS Society of Physics
Students is just more white physicists. Your typical physicists. It's
different when an older white guy comes to your poster and is asking you
all these questions and it's not really like they want to know more about
your research or just want to know what you know. It's like you're trying
to prove yourself in a sense. Through the years I have found ways to flip
the tables. That's one major difference is how you handle that one on one
conversation at your poster. Different between people testing your
knowledge versus actually being interested in your research.

When several of the students were asked what it is like to be an African American in
science at an HBCU, they expressed that their participation in the community of science was
accompanied by a higher status within the African American community. This mindset is
challenging from a CRT lens, as it points toward the hegemony of white culture (Gotanda,
1991). Thus, I propose that the experiences and perceptions of many African American
science students at HBCUs is likened to the middle-class described by Lacy (2004). This is
due to the fact that not many African Americans pursue science-related degrees or careers,
and such aspirations are often times associated with a high degree of intelligence and
financial stability. When asked what it is like to be an African American in science at a
HBCU, a senior double major in civil engineering and physics named Josiah commented:
I feel that it's a rarity, and that's outside of the school. Because there is a very big differentiation between the amount of African Americans in science, compared to Caucasians or even Asians, or people with different ethnicity backgrounds. Being a scientist at a HBCU I feel is, it's a remarkable experience, because I feel the science department is somewhat small relative to the different colleges that are on this campus. So, I almost feel like I'm part of an elitist group. Not necessarily better than anybody else, but part of a select few.

Dennis further explained what it is like to be an African American in science as a whole. He expressed that he is in one of the more difficult science fields, thus this sets him apart from other students. Specifically he states:

I feel like being that I’m a STEM major in a science-related field, and that I’m in one of the higher, more difficult science majors, I feel like I’m part of a, I wouldn’t say an elite group, but I feel like I’m part of one of the top groups in our African American population. At the end of the day, African Americans, they’re not coming to school to study chemistry or even study biology for that matter. Some say they would like to study biology, and they would like to be pre-med, but once they take a general biology course or general chemistry course, like Chemistry 101, they kind of stray away from it
because they get frightened, because they don’t do so well...Like I said, I feel like I'm at the top ... Well, not at the top completely, because I don't want to make it seem like I'm that person. I feel like I'm cut from a different cloth, as far as African American is concerned.

Seemingly, although the students have a critical awareness of science as being white property, this perceived higher status within the African American community instills in them a sense of pride that prompts the adoption of an assimilationist attitude in order to function within the domain that provided such status.

There was a significant positive correlation between Centrality and Nationalist ($r = 0.54$, $p < .001$). The correlation coefficient between Centrality and Nationalist was 0.54 indicating a large effect size. This indicates that as Centrality increases, Nationalist tends to increase. The pairwise analysis of both data sets revealed partial agreement, thus providing the opportunity to utilize qualitative data to further explain this correlation. The interactions that take place with African American/African faculty and peers within the HBCU environment promoted the development of many students’ racial centrality or nationalistic attitude. Mary, a chemistry student at North Central M&T made several comments that reflected both high centrality and high nationalist attitude; however, she expressed that she did not have a heightened appreciation for her culture prior to matriculating at her HBCU:

Being African-American to me, there's so much rich history and
culture. There are just things that African-Americans do differently
and there are different attitudes that have come from the history of
African-Americans. I feel that that is extremely important in school
and in careers...I think that being African-American has been
extremely important to me because it's motivated me to be better
because I knew that I had to be better than them.

Further, Mary indicated that the means by which she viewed being African American as
significant is through conversations with her peers. The process of racial socialization within
her black space, amongst other African American science people, has given her a greater
sense of what it means to be black. Specifically, Mary expressed how their conversations
usually honed in on racial barriers, thereby highlighting the permanence of racism in
American society; however, the exposure to racism is virtually nonexistent in the black
spaces within her HBCU.

According to Lacy (2004), many middle-class blacks participate in a form of
segmented assimilation, in that, they privilege the black world as a space for socializing
while living in a white suburb. Furthermore, they are reluctant to relinquish their connection
to the black world because this is the means by which they sustain and nurture their racial
identity; therefore, they do not fully assimilate into the mainstream (Lacy, 2004).

There was a significant negative correlation between Centrality and Public Regard ($r$
= -0.29, $p < .001$). The correlation coefficient between Centrality and Public Regard was -
0.29 indicating a small effect size. This indicates that as Centrality increases, Public Regard tends to decrease. Many of the students expressed that being African American is very important, but such comments were often times accompanied with a perception that members of the dominant group in science do not view African Americans as having the capability to do well in science. Master narratives regarding a deficit thinking ideology were pervasive in the comments mentioned by the students. LaDonna discussed her experience at her previous institution, which again is a predominantly White institution in a southeastern state:

I went to Mountain State University. It was bad because there is three percent African American and there is a stigma that if you were a black, you went there you were an athlete, and I was on a academic scholarship, so I was like, ‘Wow that sucks.’”

When the students are consistently being encouraged by their faculty to participate in research experiences, which usually involved attending or participating in conferences, they had to learn how to navigate their way into historically White spaces. Therefore, the awareness of the perceptions held by the gatekeepers in those spaces influenced the manner in which they perceived themselves as African American participants in those still restricted territories. According to Hogg, Terry & White (1995), certain situations activate certain identities making them more salient than others. While April’s, a second degree seeking pharmaceutical sciences student at Calvin University, comment revealed a heightened centrality and low public regard, it also reveals that she possesses more of an assimilationist
mindset due to her engagement at predominantly white science-related conferences:

“I think what really made me proud was just being able to go to some of the conferences and seeing that there weren't a lot of black people there but I was black and I was there. I was able to understand what was going on there. Just being able to be a part of that community. I think in the world view, the stigma and the stereotype or the expectation of black people isn't for them to be great, or intelligent, or to change the world, or do anything positive or influential, or anything like that.”

In addition to developing social skills, Hannah spoke of how her faculty intentionally mediates the assimilation process and how she views herself as an African American. More specifically she states:

The thing with faculty in my department, it’s something we talk about and address in the classroom that I think helps. Especially when we go to conferences and we’re the only black people there from a HBCU, but talking about it in that setting that only allows us to address that factor and helps us deal with it when the time comes...unfortunately it always comes. I guess with peers on campus it’s not so taboo or it’s not as big of a shock like, okay you do science. It’s nothing extraordinary to see a black person doing science. That’s really good to see.

Hannah’s comment “unfortunately it always comes” mirrors the comment of Derek Bell who
stated that “racism translates into a societal vulnerability of Black people (2004, p. 189) and that it is permanent in the United States.

One final explanation for the positive correlation between science identity and assimilation, as well as the positive correlation between assimilation and public regard, is connected to the changing racial faculty makeup of HBCUs. In 2013, the National Center for Education Statistics (NCES) published diversity statistics for 99 HBCUs. These 99 institutions consisted of the following faculty demographic: 56 percent of the full-time instructional faculty were Black, 25 percent were White, two percent were Hispanic, and ten percent were Asian (NCES, 2014). When Chris speaks of faculty members who have greatly influenced his science identity and science self-efficacy beliefs, he speaks of an Asian American instructor named Dr. Chan [pseudonym].

My mentor is Dr. Chan. Right now we are trying to develop a cross effect of chemical sensor, and test to try and detect stress levels from...He's Chinese, yes, Asian. Dr. Chan is like my favorite professor on campus.

I've had at least four classes with him now. He pretty much just motivates you to be a better student.

The increasing representation of non-African American faculty at HBCUs, in particular White and Asian faculty within science fields, appears to influence this relationship between science identity and assimilation. If students are consistently having positive interactions with White and Asian faculty, who are the dominant racial groups in science, their racial
ideology is potentially influenced to shift towards and Assimilationist attitude. In particular, if the majority-minority is welcoming and shows concern like Dr. Chan, then the students potentially perceive mainstream society and the science community as being receptive of African Americans. So while the students may have a preference for Black spaces, in particular those heavily concentrated with their African American peers, they tend to strategically assimilate into communities of practice that are heavily concentrated with White and Asian individuals. According to social identity theory, entails viewing things from the group’s perspective (Stets & Burke, 2000). The critical question is whether or not the values and experiences within these predominantly white communities of practice catalyze a release from Black cultural values, perspectives and practices. All in all, the strategic adoption of an assimilation ideology is aligned with the CRT notion of the permanence of racism because their blackness becomes less salient as they are required to interact with white scientists; therefore, racial subordination is maintained within science communities of practice that lack representation of African American role models or mentors.

**The Source Makes the Difference.** Simple regression analysis revealed that science self-efficacy significantly predicts racial centrality. Results from the qualitative aspect showed partial agreement with this outcome, as several of the accounts from students help to explain why for every unit increase in science self-efficacy the racial centrality decreases by 0.28 units. The integration of the two data sets lead to the theme: *The Source Makes the Difference.* Qualitative data shed light on the importance of considering the source that
influenced the students’ science self-efficacy to increase or decrease.

Previous studies have reported a statistically significant correlation between the four sources of self-efficacy beliefs (i.e. mastery experiences, vicarious experiences, social persuasion, and physiological arousal) and self-efficacy beliefs; however, this study did not incorporate a quantitative evaluation of the influence of these sources (Britner & Pajares, 2005). Moreover, mastery experiences have been found to significantly predict science self-efficacy beliefs, as well as to have the strongest correlation with science self-efficacy beliefs (Britner & Pajares, 2005). Previously, Britner (in press) found that African American scientists who attended HBCUs for their undergraduate studies report that the primary sources of their science self-efficacy beliefs were vicarious experiences and social persuasion. Conversely, those who attended PWIs reported mastery experiences as their primary source. A thorough analysis of the interview transcripts revealed that when the source that is promoting the increase of their science self-efficacy beliefs is mainly mastery experiences, the significance or centrality of their Blackness is not as relevant or high. However, when the source is social persuasion from or vicarious experience through interactions with a faculty member or peer who is also African American/African, the significance or centrality of their race tends to increase. When Patricia discusses her confidence in her ability to do well in her biology, chemistry or physics courses, she expresses that her high confidence level is due to past or present mastery experiences with the subject matter; however, her racial identity is never integrated into this portion of the
I think it’s increased my confidence substantially. Mainly because when I'm in my other classes, when I'm not TAing, some of the things they might not know, like a certain procedure or interpreting a figure or facts on a paper, it's easy for me because I do it all the time versus people that don't have the experience it’s more difficult for them. Its boosted my confidence because its like "wow I'm able to do this" but I have to remind myself to be humble because it’s only because I have these experiences that I know how to do these things...

Conversely, students whose science self-efficacy beliefs were augmented through vicarious experience tended to integrate a more positive appraisal of their Blackness. Specifically, when the significant other through which these experiences occurred was either African American or African, the students’ expressed a greater sense of pride in being African American. Josiah’s description of his science self-efficacy tend to be coupled with accounts of vicarious experiences and the centrality of his race. He speaks of how exposure to other African American physicists through a physics seminar class at his HBCU heightened his science self-efficacy, as well as his pride in being African American; however, his experience was fairly different when he attended a STEM seminar that
consisted of predominantly white scientists:

So when I was in the physics seminar and I was looking at the demographics of who was actually in my class, I was able to see that there was a nice bit of African Americans that was there, and I felt proud to be an African American. I felt, okay it's not going to be impossible because I am able to see that, okay there's other people that are on the same track of becoming a scientist. More importantly, when I was at a STEM seminar, and they [referring to White facilitators] were saying, "Okay. Everybody who are engineers raise your hand. Everybody who are scientists raise your hand. And, who are more important, physicists raise your hand." I think I was one of two African Americans to raise our hands. And that's almost on the other spectrum, because before my physics seminar class I was happy because there was a group of us. But then I also felt a sense of pride to say, okay, well now there's only two of us but I'm still here representing.

Further, Aniyah expressed that being surrounded by other African Americans, in particular faculty members, who have done well in science establishes a confidence that she can excel in science; however, she also expressed that she has to work hard in her science courses to earn a good grade:

Well, at Franklin State, since everyone is, basically everyone is African-
American, it's higher population of African-Americans, I can see that I can do it because I have professors who are African-American, gone through school, have done research, and have like an excellent resume. I see that now because I'm African-America, doesn't mean that I can’t achieve.

From a CRT perspective the above comment by Aniyah revealed that seeing other African Americans (i.e. faculty or peers) excel in science or being socially persuaded by individuals within their racial group seemingly counters stereotypical messages about African Americans and science; therefore, resulting in a more positive predictive correlation between science self-efficacy and centrality. For this reason, constant decreases in the representation of African American faculty (male or female) at HBCUs can have significant effects on the racial identity, science identity, and science self-efficacy beliefs of African American students.

**Science Self-efficacy and Science Achievement are Raceless in the HBCU Environment, but Otherwise Racially Concentrated.** The quantitative findings revealed that the nationalist ideology moderates the relationship between science self-efficacy and college science achievement. The predictive ability of science self-efficacy for this sample of students was provided through the triangulation of this moderation finding, the relationship between science self-efficacy and centrality and students’ remarks. I was able to qualitatively determine the significance of race (and specifically their racial group) to the students by
evaluating moments when students associated or disassociated their science achievement, science self-efficacy, and science identity with race (Pollock, 2006; Carter Andrews, 2009). In partial agreement with the quantitative findings, the students’ remarks indicate that their science achievement was deracialized within the context of their HBCU but racialized outside of that context. The contradictions in their construction of their science achievement helped to facilitate a greater science self-efficacy and academic motivation (Carter Andrews, 2009). This information resulted in the theme: *Science Self-Efficacy and Science Achievement are Raceless in the HBCU Environment, but Otherwise Racially Concentrated.*

When the students spoke of their experiences at their HBCU race was never mentioned as a determining factor in their ability to succeed. However, when their science self-efficacy beliefs were connected to the world beyond their HBCU, confidence in their ability to succeed in science became more racialized. The racial homogeneity of the institution creates an environment where science success is possible and more normative for African Americans. The interactions with faculty, and specifically peers that influence science self-efficacy are not hindered by their race; therefore, they tend to deracialize the process of succeeding within the context of their HBCU. Hannah’s remarks in that, doing science is more of the norm for African Americans within the HBCU context.

I guess with peers on campus it's not so taboo or it's not as big of a shock like, okay you do science. It's nothing extraordinary to see a black person
The vast majority of the students attributed their success and science self-efficacy beliefs to working hard, and mastery experiences. Aniyah expressed that she had to work hard to perform well in her science courses, thus her confidence again stemmed from her work ethic; however, some of their hard work was connected to seeking assistance from faculty and peers. She explained that the type of support that she receives at Franklin State is a lot stronger than what she received at United; therefore, meaningful and supportive relationships have facilitated the development of her science self-efficacy. The process of receiving help was more racially concentrated at her former PWI, thus serving as a barrier to the development of her science self-efficacy.

Okay. You can kind of tell who's a science major and who's not because the science majors are always together, they're always in the study room together. The collaboration is pretty good. Awesome. Because at my previous college, or United, you didn't see that a lot. Everyone would study independently, but at Franklin, everyone will like get together, have study groups, and explain to each other, "Okay, if you don't understand this, then I'll teach you that," and vice versa. It's a lot more student support at Franklin than at United. The science courses, I have to study a lot. I study very hard. I complete them, I pass them, I haven't failed one yet, so
I think I do pretty good. I study very hard. Also, if I have a lot of
questions, I'll see the professor after class or I also go to tutoring, too.

To this end, when the students are faced with science achievement beyond the borders
of their HBCU, hard work and interactions with peers are not salient factors in their success. At this point in the discourse, race becomes more salient; thereby, making the completion of related tasks more racially concentrated. In alignment with CRT, the shift from a deracialized HBCU context to a racialized predominantly white context is a solid example of the permanence of racism. Through the lens of CRT, the students’ counternarratives expose meritocracy as a myth that ultimately plays a role in their overall science self-efficacy and achievement. Dennis expresses that working hard in a predominantly white science context is connected to the need to not contribute to racial stereotypes about African Americans in science. Like Aniyah, he speaks of the differences in faculty support available in the two contexts. Their awareness of racial stigmas informs their perceptions of a more racialized achievement process that ultimately conflicts with their science self-efficacy development. Specifically Dennis stated he would have to work ten times as hard at a PWI, but the hard work would be due to the color of his skin; however, that still may not result in the achievement of these science goals.

I feel like I would no longer, of course, be the majority. I'd be the minority, so I feel like I'd have to work 10 times harder...because if you're going in there, you're
making C's or D's or actually failing, I feel like they'll look at you like, "Hey, this is just another African American trying to say they can handle being a STEM major, but we're clearly showing them wrong, because they can't handle the classes that they're taking." I feel like I'd have to work just that much harder to prove myself as a person, as opposed to North Carolina Central, where I can work hard, but if I just so happen to make a C or even made a B, they'll still reach out to me and say, "Hey, what can we do to help you bring your grades up?" I feel like at a PWI, I wouldn't get that same kind of treatment...I feel like it really gets someone discouraged to make them stray away from what they're actually trying to do in life. That could possibly shatter someone's dreams, basically.

The students integrated a deracialized variant of hard work into the construction of their science self-efficacy within the context of their HBCU, thus explaining the prediction of a decrease in centrality ($B = -0.28$) per every unit increase in science self-efficacy. The normative environment of successful African American science students, removed race-based stereotypes from their need to work hard and provided them with a greater confidence that success is attainable. Moreover, a strong nationalist ideology developed through interactions with their peers within their HBCU environment buffers ($B = 0.16$, $t(236) = 2.53$, $p = .012$) the effect that science self-efficacy has on achievement within the racialized world beyond HBCUs. The experiences were more racially concentrated in their predominantly white high schools, research settings, or perceptions of predominantly white institutions. As
noted by Carter Andrews (2009), the inconsistencies in how the students did not associate their confidence and science achievement with race in the HBCU context but did in other instances outside of the HBCU context serves as an indicator that the students perceived constructions of race as significant outside of the HBCU context yet insignificant to science self-efficacy within the HBCU context.

I’m going to confidently handle my business and prove-them-wrong! The comparative analysis between the quantitative and qualitative data sets revealed partial agreement, as perceptions expressed by the students further explained why the students’ science self-efficacy serves as a significant predictor of the public regard. More specifically, the students’ stories illuminated why an increase in their science self-efficacy is predictive of an increase in the way they felt members of the dominant group perceive African Americans as science persons. Given the increasing representation of White and Asian HBCU faculty, student accounts like the one expressed earlier from Chris lend to a clearer explanation of why students’ science self-efficacy beliefs predicted their public regard. Again, if they are had positive experiences with non-African American/African faculty who served as sources of their science self-efficacy beliefs (i.e. vicarious experience or social persuasion), then their tendency to perceive that other racial groups have a positive view of African Americans increased.

The various accounts from the students revealed that their science self-efficacy beliefs are potentially connected to an adaptive coping mechanism, which enabled them to
manage stereotypes. According to Steele (1997), stereotype threat is pervasive in domains that typically have an underrepresentation of African Americans, in this case science. McGee and Martin (2011) reported that academically successful African American mathematics and engineering students develop strategies that enable them to attenuate the impact of stereotype threat. They introduced stereotype management as a strategic response to the omnipresence of stereotype threat that ultimately promotes academic success (McGee & Martin, 2011). While the students in this study have an awareness of the racial stereotypes concerning science performance of African Americans, they have developed strategies to counter the stereotypes. Based on the students’ remarks, I have concluded that their confidence in their ability to excel in science (and actually manifesting such success) is connected to a confidence that their success will improve societal perceptions (public regard) about African Americans. Essentially, their science self-efficacy is connected to a strong motivation” to prove them wrong”.

The “prove-them-wrong syndrome was originally proposed by Moore et al. (2003) to provide an explanation the persistence of African American males in pursuit of obtaining a degree in engineering. The team discovered that the syndrome stemmed from a psychological phenomenon that emerges due to larger societal projections of an image of Black intellectual inferiority (Howard & Hammond, 1985). The quantitative data supplemented by qualitative findings from this study and those reported by other researchers led to the theme: I’m going to confidently handle my business and prove-them-wrong!
The notion of proving the various racial stereotypes wrong was consistent across many of the students’ comments. In most cases, this motivation began during high school as a result of the students being one of few if not the only African American student in their predominantly White science and mathematics courses. For instance, Hope asserted:

It was different at times being the only black kid there. There was definitely extra effort for me being the only black student. I didn’t want to be struggling in classes or anything...That’s one thing that I didn’t want to be, a stereotype, and be in class and playing around. I was focused and made sure I handled by business and did everything I was supposed to do.

The students’ awareness of racial stereotypes that resulted from either their own personal experiences or those of African American scientists that serve as role models constructed a strong work ethic to disprove societal perceptions regarding their racial group. Mary spoke of the importance of showing people what African Americans can do, which was birthed out of both vicarious and personal experiences. The fact that her mentor was able to defy the odds gave her an even greater confidence that she would be able to do them same; thereby, influencing at least a small subset of society.

I think it’s extremely important to show people what African Americans can do. For example, my mentor, she attended a program and there was
students from Harvard University, from all these Ivy League schools. People didn’t believe in her because she was black, but she really proved them wrong...When people would talk about race and the challenges that come with that, I didn’t really see it so much in my high school. I think in people’s speech and actions there were some racial undertones and I think I saw that, but I think that just made me want to prove them wrong.

While the students expressed the need to prove-them-wrong within the context of science-related racial stereotypes, they did not feel like they had to utilize this strategy within the context of their HBCU. Through a thorough evaluation of their accounts, it became evident that the HBCU environment buffered the impact of stereotype threat and a perpetual need to prove racial stereotypes to be invalid.

Serving as buffers of the impact of racial stereotypes, each of the institutions instilled in their students that they have the ability to prove racial stereotypes to be wrong. Many of the institutions have faculty members who established high expectations which built the students’ science self-efficacy; thereby, positioning them to counter stereotypes. The students’ personal self-efficacy matched with faculty expectations ignited a drive for success. Instead of students being situated in learning environments that were saturated with low expectations, thus reinforcing the negative stereotypes, they were positioned in environments that sent the message that they were capable of defying stereotypes.

In addition to setting high expectations, many students expressed that their faculty
pushed them to understand the material; therefore, pushing them beyond stereotypes and standards established by dominant culture. This “push” by faculty is characteristic of a concept known as “academic press”. Academic press is the summation of environmental pressures that prompt students vigorously pursue their academic goals (Murphy, Weil, Hallinger, & Mitman, 1982; Shouse, 1995). Moreover, it has been described as an essential quality of effective schools, as academic press influences student academic norms, student self-concept of academic ability, and student sense of academic self-efficacy (Murphy, Weil, Hallinger, & Mitman, 1982). Press for understanding has been reported to positively predict academic self-efficacy (Middleton & Midley, 2002). The press for understanding the material covered in the sciences courses built the students’ sense of competence, which in turn built their science self-efficacy
CHAPTER V: SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

This study investigated the relationships that exist between the racial identity, science identity, and science self-efficacy beliefs of African American students enrolled at HBCUs. While each of the constructs had been explored separately, their interrelationships have not received widespread attention. Moreover, the role that the HBCU environment in supporting or affirming the development or interactions of these constructs has not been explored. Through a concurrent mixed methods design (QUANT + qual), the perceptions of the participants were captured to provide a richer description of the quantitative findings. The purpose of this chapter is to provide potential answers to the four research questions, summarize the findings, explain the implications of the study, and provide a set of recommendations for future research based on the findings.

Summary of Study

A plethora of reports indicate that African Americans are highly underrepresented in the various domains of science. While the primary narratives have reinforced a deficit thinking model, other potential contributors to the science success of African Americans have not been widely investigated. This study explored the relationships that exist between the racial identity, science identity, and science self-efficacy beliefs of African American college students. In particular, the study sought to illuminate the role of HBCUs in supporting the development of the three constructs, as HBCUs produce a disproportionately high number of African American scientists.
In order to gain insight into each of these questions, 407 African American science students (i.e. Chemistry, Biology, Physics, and Pharmaceutical Sciences) enrolled at five HBCUs located in a southeastern state responded to surveys. The Multidimensional Inventory of Black Identity (Sellers, Smith, Shelton, Rowley, & Chavous, 1998) was used to determine their racial identity, specifically I used the following subscales: Centrality, Nationalist, Assimilationist and Public Regard. The Science Identity Scale (Chemers et al., 2011) was used to determine their science identity, while a modified version of Nietfeld, Cao, and Osborne’s (2006) Educational Psychology Self-Efficacy inventory was used to determine their science self-efficacy beliefs. Moreover, fourteen students participated in 40-60 minute semi-structured interviews. The participants were sophomores, juniors or seniors.

Quantitative findings did not support the hypothesis that racial identity serves as a moderator for the association between science identity and self-efficacy beliefs. However, quantitative findings did support the hypothesis that there is a positive correlation between racial identity and science identity. Surprisingly, the Assimilationist ideology was the dimension of racial identity that demonstrated a positive correlation with science identity ($r = 0.17, p = .005$). This result extends findings from previous studies that have shown African Americans with a higher socioeconomic status have an affinity for black spaces but display a pattern of strategic assimilation into mainstream society (Lacy, 2004). According to the MMRI, an African American science student ascribing to an assimilationist ideology may underscore adapting to the mainstream American culture. Sellers et al (1998) posit that
assimilationists believe that it is necessary to utilize the current system to effect systematic social change as an active participant within that same system. Therefore, many of the participants may perceive it necessary to blend into and adopt dominant science norms to promote social changes related to race (Bimper & Harrison, 2011). According to CRT, it is possible that the adoption of a colorblind assimilationist viewpoint destroys aspects of their Blackness and dilutes the value ascribed to Black culture (Gotanda, 1991). When the correlation between Assimilation and Science Identity was evaluated in the presence of students’ remarks, the partial agreement of the merged data resulted in the themes: “I prefer Black Spaces, but I strategically Assimilate.” It is highly probable that African American science students at HBCUs adopt an assimilationist ideology as a coping strategy within the white structural framework of science. An additional quantitative data point that facilitated the emergence of this theme was the significant negative correlation between the number of college sciences courses and Assimilation ($r = -0.15, p = .031$). Carlone and Johnson (2007) reported that recognition, performance and competence are key factors that foster the development of students’ science identity. According to the participants, their institutions and departments heavily promote participating in authentic research, internships, and conferences. These activities foster the development of the students’ science identities, as they provide them with opportunities to be recognized as scientists, build their science knowledge base and put their science knowledge into practice. While some of their research experiences are on their campuses with their faculty members, many of the opportunities are
beyond the borders of their HBCU. Therefore, the students strategically navigate their way across boundary lines into historically White spaces (Assimilation) as their science identity develops, even though they have a strong preference for Black spaces. Within the Black spaces (i.e. their HBCU) they are surrounded by like-minded African American peers, and in most cases African American faculty, which allows them to preserve and further develop their racial identity. The racial socialization that occurs amongst peers and African American faculty strengthens their racial centrality.

The experiences of a few students shed light on the demographic makeup of the faculty at each of the HBCUs, in that there is a relatively high number of non-African American/African faculty. Thus, the positive correlation between their science identity and assimilation may be due to positive interactions between students and non-African American/African faculty. This finding is very significant as it has the potential to help science faculty at PWIs see the positive impact of consistent and meaningful interactions with African American science students in their program. Many of the students perceived that their experiences at PWIs would be drastically different, to the degree that they probably would have aborted their aspirations of becoming a research scientist or doctor. Some of the students who transferred from PWIs or conducted research at PWIs shared experiences that affirm the perceptions of those participants who did not have the same experience. Many of the non-African American/African faculty members have learned how to engage appropriately with the students, while others have only affirmed racial stereotypes through
their discourse. Those who have positive relationships with the students have impacted who they are as scientists, and catalyzed the adoption of an assimilation mindset that helps them to function within predominantly white spaces. This is a lesson that is transferrable into PWI environment.

There was not a statistically significant relationship demonstrated between science self-efficacy and any of the racial identity dimensions. However, quantitative findings showed that the Nationalist ideology moderates the relationship between science self-efficacy and achievement. Given the novelty of this finding to the body of existing literature on racial identity and science self-efficacy, it is important that they be replicated in future research. A significant negative correlation was shown between science self-efficacy and science identity. Additionally, quantitative findings revealed that science identity is a significant predictor of science self-efficacy beliefs. Surprisingly, for every unit increase in science identity, there is a decrease in science self-efficacy of 0.41. Rarely have quantitative studies captured that science self-efficacy is a predictor of science identity; however, several qualitative studies have reported that students perceive that increases in their science self-efficacy result in increases in their science identity (Hunter, Laurenson & Seymour, 2006; Aschbacher, 2010). The findings from this study showed that science self-efficacy was a significant predictor of science identity ($B = -0.28$). This predictive finding differs from findings from previous studies (Robnett, Chemers, and Zurbriggen, 2015; Williams & George-Jackson, 2014), in that these studies indicated that increases in science self-efficacy
are predictive of increases in science identity. For this reason, it would be worth considering other factors that may either moderate or mediate the relationship between the two variables specifically for African American college science students at HBCUs. Another viable consideration may be looking at these relationships by classification and gender to see if there are considerable differences in the interactions between science self-efficacy and science identity.

With regards to research question two, the regression results showed that science self-efficacy is a significant predictor of college achievement GPA ($B = -0.26$), with this relationship being moderated by the Nationalist ideology ($B = .16$). This finding is misaligned with previous studies, which reported that science self-efficacy predicts a positive increase in science achievement (Britner & Pajares, 2001). Additionally, simple regression analysis revealed that science self-efficacy is a significant predictor of centrality ($B = -0.28$). The hypothesis that racial identity mediates the relationship between science self-efficacy and college science GPA was not supported by any of regressions (i.e. centrality, assimilation, nationalist, public regard). However, partial agreement between the qualitative data and the quantitative finding regarding the relationship between science self-efficacy and centrality lead to the theme The Source Makes the Difference. The qualitative findings reveal that it is important to consider the source that is informing students’ science self-efficacy beliefs (i.e. mastery experiences, vicarious experience, social persuasion, and physiological). Moreover, it is essential to consider the “who” for vicarious experiences and social
persuasion, in that, is the source an African American faculty, non-African American faculty, or a peer. The students’ remarks revealed that when the students’ science self-efficacy increases due to mastery experiences, the predicted outcome to be a decrease in their centrality. On the other hand, vicarious experiences with another African American or social persuasion from another African American is predictive of an increase in their centrality. Engaging in science activities with other African Americans and experiencing success in the task vicariously through them or receiving encouragement from them counters negative stereotypes that African Americans cannot be successful in science. Additionally, a deeper analysis of the students experiences revealed that when they described their science experiences within the context of their HBCU they did not simultaneously speak of their race; however, race tend to resurface when their science self-efficacy was discussed in contexts outside of their HBCU. This discovery resulted in the theme: Science Self-Efficacy and Science Achievement are Raceless in the HBCU Environment, but Otherwise Racially Concentrated. These finding more appropriately addresses question one, as it speaks of the relationship between the constructs instead of how their interactions influence college science achievement.

Simple regression results also showed that science self-efficacy was a significant predictor of Public Regard, $B = 0.26$. This finding yields support the notion that African American’s intellectual performance and confidence can be disrupted under stereotype threat conditions (Steele and Aronson, 1995). Such a finding further affirms the CRT notion of the
permanence of racism, as the perception of members of dominant culture weighs heavily on the overall science success and confidence of African American students, even within a predominantly Black context. The increased representation of White and Asian HBCU faculty plays a key role in this predictive relationship, as illuminated by students’ lived experiences. From a CRT perspective, the increased representation of White and Asian HBCU faculty, as well as their influence on the relationship between science self-efficacy and public regard, lends to the notion of whiteness as property. Essentially, these faculty members exercise their rights to exclude by the type of learning experiences they design for the students. If the students struggle with the material, in the presence of White and Asian faculty who do not affirm their abilities, then they may perceive that the larger science community will view them incapable and unwelcomed into the community.

A second explanation stemming from the students’ shared accounts is that the science self-efficacy beliefs of African American college students is potentially connected to an adaptive coping mechanism that assist students with managing racial stereotypes. Given that the students are operating in a domain that is saturated with prevailing stereotypes about their ability to succeed, their science self-efficacy is connected to a strong motivation” to prove them wrong”. This result extends findings reported by Moore et al (2003), which suggested the “prove-them-wrong syndrome” as an explanation to understand the persistence of high achieving African American males in engineering disciplines. This coping mechanism reveals the endemic nature of racism in science, due to the fact that the students are not just
working hard to establish competence but to dismantle stereotypes. It lends to a subordinate position that African American students have within the domain of science, further strengthening the CRT notions of the permanence of racism and meritocracy as a myth. The students expressed the need to work hard, in order to be competitive candidates for graduate school and/or pre-professional health school; however, they were keenly aware that their hard work alone did not guarantee their admission. I propose that the HBCU environment buffers the impact of the racial stereotypes that the students are faced with managing, more so when they engage in science-related activities beyond the boundaries of the institution.

Research question three explored the pre-college experiences of students to determine the impact they had on their college science achievement. Moreover, science identity was not found to be a significant predictor of college science achievement. The data did not support the moderation hypothesis; however, several statistically significant correlations were identified. There was a significant negative correlation found between high school GPA and Science Identity ($r = -0.14, p = .047$). This was explained by a lack of exposure to opportunities to perform science, a lack of participation in science communities of practice and African American role science models. This finding highlights the CRT notions of the permanence of racism, as well as whiteness as property. For students who attended predominantly Black high schools, a systemic form of racism resulted in their schools not having resources that were equivalent to predominantly white high schools; therefore, they were not presented with the same opportunities to practice science. While they may have
thrive academically, they did not receive the recognition or performance experiences needed to shape how they perceived themselves as science people. Conversely, the science identities of students who may have attended predominantly white high school may have decreased due to being the only African American in their science and math courses; thus, they did not have anyone to identify with as a scientist. Moreover, white counselors and teachers may have exercised their right to exclude by not informing the students of science clubs and programs, which was the case for participants like Patricia. There was a significant negative correlation found between high school GPA and Assimilation \((r = -0.15, p = .031)\). There was not significant qualitative data to explain this correlation, thus future studies will be shaped to better explain this occurrence. There was a significant negative correlation between high school GPA and Public Regard \((r = -0.19, p = .005)\), which was explained by racialized experiences the students had with their White counterparts in high school. Again, this finding fortifies the CRT notion of the permanence of racism in our public schools. While the students reported good success in their high school science and math courses, such success was accomplished in the midst of discrimination and racial microaggressions.

Several novel correlations were found through this study. There was a significant positive correlation between Science courses in college and Centrality \((r = 0.15, p = .031)\). There was a significant negative correlation between Science courses in college and Assimilation \((r = -0.15, p = .031)\). The structural characteristics of the HBCUs, as described by the participants, positions them to engage more frequently with their science peers and
African American faculty; thereby fostering a more positive appraisal of their Blackness. Resultantly, the students’ tendency or need to assimilate decreased because they are receiving the support that they need through these interactions to successfully navigate their way through science as an African American. There was a significant negative correlation between Science courses in college and Public Regard ($r = -0.27, p < .001$), which was explained by negative interactions with non-African American faculty over the course of their time at the institution. Even within an HBCU context, students experience racism due to the changing face of HBCUs and the type of science-related experiences the students have outside of their home institution. The permanence of racism within our institutions of higher education may be more salient in domains like science due to the underrepresentation of African American scientists in the larger science community.

The fact that there are more non-African American faculty position within HBCUs is an indicator of the reification of race within higher education. I ground this point in the CRT concept of reputation as property (Harris, 1993). Many interview participants expressed that society questions the quality of the education that they receive from a HBCU, which is aligned with the notion that to “identify a school or program as nonwhite in a way is to diminish its reputation or status” (Ladson-Billings & Tate, 2006, p. 23). For this reason, many HBCUs and specifically science programs have sought to increase the reputation of their institution or program by employing more white or honorary white (Asian) faculty members. Additionally, the low representation of African American faculty at HBCUs is
reflective of the white right to exclude, which has minimized the number of African American students to receive an undergraduate degree and more importantly a doctoral degree in science.

The students expressed a common struggle that they experienced within and outside the confines of their HBCU. This shared struggle as African Americans pursuing science facilitated the development of both their racial and science identities. However, one must consider those students who are not able to positively identify with the struggle and recognize the potential benefits of its existence. Do they submit to the struggle and the oppressive structures that are affiliated with it, thereby relinquishing their racial and/or science identities? According to Ogbu, the awareness of institutional, systemic or structural impediments to upward mobility causes African Americans to privilege their collective identity and favor their collective struggle as a coping mechanism (Ogbu, 1989). Essentially, the students’ collective struggle is critical for attenuating or eradicating the barriers to their mobility (Ogbu, 1983).

Beyond the financial struggles, the students reported that when they face academic struggles, their instructors do not discourage them from continuing but encourage them in a way that allows the students understand their struggle. The academic “struggle” faced by many of the students within their college science courses is due to a lack of available resources (i.e. highly qualified teachers, rigorous curriculum, science organizations/programs, etc.) at their high schools. To this end, their present day “struggle”
in science is due to an existing racism within the American educational system, as emphasized by CRT. Ladson-Billings and Tate (2006), suggested that the condition of schools and schooling for African American students is due to institutional and structural racism. Furthermore, Kozol (1993) asserts that the white property rights to use and enjoy has resulted in students who attend “white schools” having access to curriculum that place an emphasis to critical thinking, reasoning and logic, while students attending urban/Black schools are not granted the right to use and enjoy such curricula.

For this reason, many African American students transition to college with an almost prophetic destiny to struggle through their science courses, until they develop the capacity and competence to think on a more critical level. The struggles faced by the students at the five HBCUs are varied yet similar to one another. Moreover, they are unique to African American students; therefore, the expressed struggle further affirms the CRT tenet to challenge meritocracy. The students are face with very weighty struggles, and the need to work “ten times” harder, while simultaneously competing with white students who may have struggles but those struggles are accompanied with white privileges.

Each of the institutions enhanced students’ science cultural capital through faculty interactions, peer interactions, rigorous curricula, authentic research, and community/organizational involvement. Many of the students who participated in the interview portion of the study, did not come from families that included a person working within a science-related career; therefore, their science cultural capital would be considered
This vital aspect of their cultural capital must be critically examined through the CRT tenets of whiteness as property and challenge dominant ideology. The mere fact that the vast majority of students attending HBCUs, as represented by the students in the qualitative aspect, come from families that lack scientist lends to the notion of science as white property. While many of their white counterparts are able to benefit from such a right being transferred from generation to generation, these students are faced with a science experience that has essentially excluded everyone in their lineage. To this end, low science capital due to the lack of scientist in their families reifies the CRT notion that meritocracy is a myth. If in fact, their white counterparts are entering the science playing field with science capital due to a right to participate in science being passed down in their families, then the playing field is not equal. For this reason, they have an advantage as it relates to the science-related experiences, both inside and outside of the classroom.

**Research Study Limitations**

Although this study produced significant findings, there are several limitations that may have impacted the outcome of the findings. One of the limitations of this study was the sample size. The initial power analysis suggested a sample size of 550 students, but I was only able to recruit 407 students. Since all of the students did not complete the entire survey portion, the number of useable results reduced the sample size to 346 students. With that said, the study lacked the precision to yield strongly reliable quantitative results. In addition
to the size of the sample, there was an unequal distribution of across majors and institutions. For example, there are significantly more African American biology participants across each of the institutions, the vast majority of the biology came from North Central M&T. This limits the generalizability of the findings. Additionally, the representation of African American science faculty members varied across the five institutions, which may have resulted in a differentiated development of the three constructs of interests within the student participants. Another limitation regarding the sample is the inclusion of sophomores. It is possible that the outcomes would be different if only juniors and seniors were included in the study, as they have experienced the institutional context and field of science more than sophomores. Moreover, they would have more experiences within and outside of the boundaries of the institution to inform their appraisal of their racial identity, science identity, and science self-efficacy beliefs. Last, the participants for the qualitative aspect may not have been a strong representation of the larger sample. Several of the participants for the qualitative aspect were recruited out of programs designed for higher achieving students who intend to go into research/pursue a PhD (i.e. MARC) or they were high achieving students within their respective departments. Therefore, they may have had experiences that were not common to all science students. While this was not the case for all of the qualitative participants, the vast majority of them fit this description of high achieving students. The original intention was to include more HBCUs in this study to increase the generalizability of the results; however, the involvement of only five HBCUs plays a role in the strength of data
Due to the demographic survey and scales being self-report, there is a strong likelihood that all of the reported data is not totally accurate. In fact, some of the students provided an overestimation for the number of high school science and mathematics courses, and did the same for college level courses. Moreover, it is very likely that students did not accurately report their high school GPA and college science GPA. I believe many students reported their cumulative college GPA for their science GPA.

With regards to the design of the study, I believe an explanatory sequential mixed methods approach would have allowed me to gain richer descriptions of the data. This statement is made because I realized during the data analysis and integration that collecting the quantitative data prior to conducting the interviews would have allowed me to ask questions that specifically addressed the most salient quantitative findings. For example, knowing that there was a positive correlation between science identity and the assimilation ideology (racial identity) would have allowed me to ask specific questions about the students’ experiences that may have contributed to this relationship. Moreover, it would have allowed me to ask whether or not the students perceive if they have an assimilation ideology.

Last, as an African American female scientist who is full-time faculty at an HBCU, I serve as both a limitation and strength to this study. Due to my position at one of the HBCUs included in this study, I was not able to interview the biology students; therefore, their perceptions of their science experiences were not included in this study. This is unfortunate
because they represented a significant percentage of the students included in the quantitative aspect of the study. Conversely, my position provided me with greater access to the students for the study, because my colleagues were able to foster connections with faculty members at the five institutions. Moreover, colleagues at my employing institution granted me the opportunity to recruit their students either face-to-face or through their Blackboard sites.

From the beginning to the end of this study, I was conscious of addressing my own biases due to my personal experiences. As an insider, I have an awareness of some of the experiences of African American students and specifically those enrolled at HBCUs. Such insight assisted me with the qualitative aspect, it gave me insight into the potential experiences that serve as sculptors of the participants’ identities; therefore, I was able to ask appropriate questions that yielded a more grounded understanding of the various contextual influences.

**Implications**

The utilization of CRT as an analytic lens to evaluate the science experiences of African American students in higher education has been very minimal. The present study not only framed every aspect using the central tenets of CRT, but incorporate additional substantive theories to develop a comprehensive framework to unpack the developmental process of racial identity, science identity and science self-efficacy beliefs of African American students. Very rarely have studies investigated these psychological constructs in African American students, in particularly those who are enrolled at HBCUs. Given the
disproportionately high number of science graduates produced by HBCUs, this study gives sheds light on the facilitators of the successes and struggles of many African American students who pursue science degrees at HBCUs. Most studies that have investigated the constructs of interest separately and qualitatively. Therefore, the utilization of a mixed methodology provided a richer, fuller understanding of the relationships that exist between the constructs of interests and the role of HBCUs in their development.

The quantitative findings merged with the students’ lived experiences shed light on relationships that exists between racial identity, science identity, and science self-efficacy beliefs. Most importantly, their accounts explain the role of HBCUs, which can serve as a pattern for faculty and decision makers at PWIs. Several implications for practice can be derived from this study. Moreover, the findings may be used to inform the development of policies and practices that impact the science journeys of African American students.

While the findings show that students perform at an above average level in high school, it also shows a significant negative correlation between their achievement and science identity. The results from this study can be used by K-12 administrators to ensure that they position African American teachers within their science classrooms. The lack of exposure to an African American role model in their science classes combined with the lack of a role model in their families causes their science identity and science cultural capital to be weaker even though they are achieving at high levels. It is also critical that high school teachers and guidance counselors increase African American students’ awareness of science-
related clubs and enrichment programs. Many students indicated that they did not know about such opportunities or they were not available in their high schools. The missing opportunity to participate in science communities of practice can potentially interfere with the development of students’ science identity, as well as their science self-efficacy beliefs. Optimally, a collaboration to develop minority-based science enrichment programs between high schools and universities could potentially result in the development of students’ science and racial identities. Research should be conducted using the analytic lens of critical race theory to identify the inequalities in access to these types of communities of practice and the long-term impact they have on students’ persistence in science disciplines. It is also critical that K-12 teachers and administrators institute systems that will minimize exposure to overt and covert forms of racism.

While HBCUs produce a significant proportion of African American scientists, the findings highlighted two areas that should be evaluated and adjusted. Although North Central M&T has a relatively high population of African American/African science faculty, such was not the case at the other institutions. The face of HBCUs has changed over the years, which has its positives and negatives. It is critical for HBCU administrators and decision makers to ensure that there is a representation of African American science faculty that matches their student body. As demonstrated by the data, and increase in the students’ science self-efficacy beliefs predicted a decrease in their racial centrality; however, qualitative findings explained that an increase in their science self-efficacy would potentially predict an increase in racial
centrality when the source of their science self-efficacy is vicarious experience or social persuasion from an African American faculty member. There is a strong need to have a diverse science faculty, as positive interactions with White and Asian faculty have the potential to increase students’ science identity and ability to transition into mainstream domains of science. However, HBCUs cannot become so racially diverse that African Americans become invisible within their faculty population, especially African American female faculty.

The female participants in this study expressed a shared experience that differed from the male participants, in that they experience a triple pressure as scientists due to the intersection of their race and gender. The underrepresentation of African American female science faculty at HBCUs, especially within physics and chemistry, has made it very difficult for these budding female scientists to connect with a role model. While the students perceived that African American male faculty have done an above average job with encouragement and fostering connections, they are not able to fully identify with the dual discrimination (i.e. racism and sexism) experienced by the female students. Future studies should delve deeper into the unique experiences of African American females who are pursuing science degrees at HBCUs, and how these experiences shape their science and racial identities. Additional CRT research should be conducted at HBCUs to explore racial microaggressions experienced by African American students in science, as these areas tend to be heavily concentrated with non-African American faculty.
Many of the students either perceived PWIs as being unwelcoming, which was confirmed by students who transferred from PWIs to HBCUs. While racism will always saturate the PWI environment, its effects can be attenuated through the implementation of some of the HBCU practices revealed in this study. My first recommendation is that PWI administrators and decision makers increase the representation of African American science faculty. In doing so, they will begin to experience an increase in the science retention and persistence of African American students, as their will be more individuals within their learning space with who they may identify. With regards to identification, as expressed by the students in the study, they need to have those faculty members in place who can fully identify with their “struggle”.

This study presents evidence that positive interactions with White and Asian faculty has a significant impact on students’ science identity, in particular when these science gatekeepers take time to recognize the successes and potential of African American students. When the students are able to perceive that the racial groups that have historically dominated science do not affirm racial stereotypes through their words or actions, they interpret that they will have similar experience in the larger realm of science. Therefore, the process of transitioning into the mainstream science community becomes easier. It is important for non-African American faculty members at PWIs to establish meaningful connections with their African American students, acquire a knowledge of their personhood, and intentionally recognize who they are as scientists. Additionally, faculty at PWIs should mirror the HBCU
efforts to connect their African American students with research experiences, internships, and organization. Furthermore, faculty can integrate a service-learning component into their courses that encourage students to take the science that they have learned in the classroom into nearby African American communities, programs and schools.

According to the students, interactions with their African American science peers significantly impacted how they view themselves as both African Americans and scientists. Due to the structural characteristics of HBCUs, instructors are able to increase engagement amongst students, while outside of the classroom students continue the engagement. This is sometimes difficult at PWIs due to their large size. Thus my fourth recommendations is to establish a Black Scientists Club/Organization would provide a critical mass of like-minded Black individuals who may serve as catalysts to the development of various dimensions of their racial identity, science identity, and science self-efficacy. Additionally, it is vital for HBCUs to ensure that their students are engaging in external science-related programs or research experiences that provide the opportunity to interact with African American science faculty or PIs. In order to foster a positive interaction between the students’ science self-efficacy and college science achievement, it is critical that they interact with accomplished African American scientists who can augment their racial centrality and a nationalist ideology.

**Recommendations for Future Research**

Several implications for future research were revealed through this study. First,
repeating the study as an explanatory sequential mixed methods study (QUANT → qual) would allow for a stronger elaboration of the quantitative findings. As I reflected on the efficacy of employing a concurrent approach for this study, I realized that I was not able to address several of the quantitative findings through the semi-structured interviews. One of the primary goals of a mixed methods study is to capture and report rich, descriptive data. I strongly feel that utilizing a sequential explanatory methodology would have allowed the opportunity to acquire more insight through the students shared experiences.

Second, researchers should further explore the positive relationship between science identity and assimilationist ideology of African American students at HBCUs. A deeper understanding of this point could be useful in providing recommendations to PWI science faculty and administrators. From a CRT perspective, it is important to look deeper into this relationship as critical race theorists contend that the social goal of assimilation destroys significant aspects of Blackness (Gotanda, 1991). It is important that African American students are able to maintain a Black racial consciousness while simultaneously participating in the Eurocentric norms of science; otherwise, relinquishing their Black culture for the sake of science engagement only perpetuates the racial subordination that is endemic in American society. It fortifies the notion that individuals from dominant society regulate who participates in science and how they participate in science.

Third, incorporating a scale that identifies the sources of science self-efficacy (i.e. vicarious experience through peer-peer interactions, mastery experiences, social persuasion
from African American faculty member, etc.) into this study would provide further insight into the factors that are supporting students’ science self-efficacy the most at HBCU; therefore, providing a richer understanding of the negative predictive relationship between Science Self-Efficacy and Centrality. Shunck (1986) suggests that students’ self-efficacy may be informed by multiple sources with a ranking system being instituted to determine the most influential source. Gaining a better understanding of the primary sources that influence students’ science self-efficacy can help instructors better structure their learning environments to promote the growth science self-efficacy and racial centrality. Fourth, student results indicated a significant negative correlation between science identity and science self-efficacy. Therefore, a follow-up study should be conducted to gain additional insight into the validity and nature of this relationship. This study tested a moderation hypothesis for racial identity, but it would be worthwhile to investigate if the various racial identity dimensions mediate the relationship between science identity and science self-efficacy beliefs. Moreover, the majority of the participants who participated in this study were engaged in science-related clubs and authentic research experiences because these activities are highly emphasized by their departments. Thus, capturing this information and exploring mediation and moderation hypotheses would provide more insight into the impact communities of practice have on the interactions and development of these key constructs.

Fourth, future studies should include the use of racial identity profiles (Harper & Tuckman, 2006; Whitaker & Neville, 2010). The application of MIBI racial identity profiles
takes into consideration that the racial identity dimensions do not act independently of one another. For this reason, future investigations should include racial identity profiles to address the relationships explored in the current study. A possible research question is: Does an association exists between racial identity attitude profiles/clusters and science identity? Based on the findings of the present study, a potential racial identity cluster to consider for future studies would include: a high level of centrality, a high level of nationalist, and low public regard. Last, replicating this study as a comparative study, in that researchers would include African American science students from HBCUs and PWIs, would provide a deeper understanding of the role the institutional context plays in facilitating the development of and interaction between students’ science identity, racial identity, and science self-efficacy beliefs.

**Conclusion**

The primary purpose of this study was to determine the relationships that exist between the racial identity, science identity, and science self-efficacy beliefs of African American science students who attend historically Black colleges and universities. This study utilized a concurrent (QUANT + qual) mixed methods approach, which provided a richer and fuller description of the findings. Moreover, the qualitative aspect gave the students an opportunity to voice the lived experiences in an effort to counter dominant narratives regarding African American science achievement. It is critical that we understand how the institutional contexts, in this case HBCUs, influence the development of these constructs due
to the significant number of HBCU science graduates. Several themes emerged as a result of integrating the quantitative and qualitative findings. Viewing the data through the analytic lens of Critical Race Theory produced counterstories that allowed the shared and individual lived experiences of the students to be heard. Moreover, the findings provide an even higher platform for HBCUs to stand upon as a model for cultivating and fortifying the aspects of African American science students’ self-concept that impact their science achievement and persistence.
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Appendix A: Survey Recruitment Letter

Recruitment Letter/Script for Survey

To Whom It May Concern:

A dissertation study led by Angela M. White, a doctoral candidate at North Carolina State University, will investigate the relationships that exist between the racial identity, science identity, and science self-efficacy beliefs of African American students in science (i.e. Biology, Chemistry, and Physics) who attend historically Black colleges and universities. Moreover, this study will evaluate the impact each of these factors has on the academic performance/success of African American students in science. The study will assess the role HBCUs play in facilitating the development of African American science students’ racial identity, science identity, and science self-efficacy beliefs (i.e. confidence in your ability to complete science related tasks or courses), as well as the relationship between each of these factors. This study is important because it will inform the development of more targeted intervention, programs, and teaching practices that focus on the academic success of African American science majors at both HBCUs and predominantly White institutions.

The researcher invites you to participate in her dissertation study where you will be asked to complete a short online survey about your personal work experiences. The questions will ask you about your personal racial identity, science identity, and science self-efficacy beliefs. Additionally, you will be asked to provide basic demographic information such as your age, race, college major, and science courses taken in both high school and college. It should take about 30 minutes to complete the entire survey that can be accessed via the following hyperlink: XXXX.

I greatly appreciate your assistance in making this research study possible and would also ask that you electronically forward this solicitation to other African American science majors who attend HBCUs who may like to participate via your Facebook friends, listserv members, fraternity and sorority brothers and sisters and your student organization members. After completing the survey, participants will be given an option to enter a random drawing for one of three $25 gifts cards redeemable at a major national retailer.

If you have any questions related to the study, please feel free to contact Angela White. She can be reached at amwhite@ncsu.edu or by telephone at XXX-XX-XXXX.

Sincerely,
Angela M. White, PhD Candidate
North Carolina State University
Appendix B: Surveys Consent Form
North Carolina State University
INFORMED CONSENT FORM for RESEARCH
(Survey)

Title of Study: Understanding the Relationships Between the Racial Identity, Science Identity, and Science Self-efficacy Beliefs of African American Students at HBCUs.

Principal Investigator: Angela M. White
Faculty Sponsor: Jessica DeCuir-Gunby, Ph.D.

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of research studies is to gain a better understanding of a certain topic or issue. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.

What is the purpose of this study?
Science, technology, engineering, and mathematics (STEM) careers provide great financial stability and are expected to experience a boom within the job market; however, very few African Americans are entering into or persisting through these fields to experience these advantages. In order to help change the direction of a declining representation of African Americans in science disciplines, this study seeks to accomplish four critical goals. One aim of this study is to gain a deeper understanding the relationships between science identity, racial identity, and science self-efficacy beliefs of African American students attending HBCUs. This study also seeks to explore the extent to which these constructs influence the science achievement of African American students attending HBCUs. Third, the study will investigate the degree to which the pre-college experiences of African American students attending HBCUs influence science identity, racial identity, and science self-efficacy beliefs, and college science achievement. The last aim of this study is to gain a more detailed understanding of the ways the African American students’ perspectives of their experiences at HBCUs influence their science self-efficacy beliefs, science identity, and racial identity.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to complete four short questionnaires. The first questionnaire is a demographic questionnaire, which is intended to capture some general background information (i.e. age, major, classification, etc.). The remaining questionnaires will be
based around science identity, racial identity, and science self-efficacy beliefs. It will take no longer than 30 minutes to complete the questionnaires, which will be completed online or during a class period. In Class Form will state: Please note that this is not a part of your course requirement, thus it will not influence your grades or standing in the course. If you choose to not participate in this survey, I would like for you to complete an alternate activity that is unrelated to this study while your peers complete the survey.

Risks
There is very little risk associated with this study. It is recommended that you complete the surveys in a private location and clear and close your browser when you have completed the surveys.

Benefits
As a participant you will gain a greater awareness of your racial identity, science identity, and science self-efficacy beliefs and possibly insight into how these factors impact your performance in science.

Confidentiality
The information in the study records will be kept confidential to the full extent allowed by law. Data will be stored securely on a password-protected computer and in a locked file cabinet, which is only accessible by the researcher listed above. No reference will be made in oral or written reports that could link you to the study.

Compensation
You will not receive any compensation for participating in this study; however, you will be entered into a random drawing to win a $25 gift card. If you withdraw from the study prior to its completion, you will not be eligible for the gift card drawing.

What if you have questions about this study?
If you have questions at any time about the study or the procedures, you may contact the researcher, Angela M. White, at amwhite@ncat.edu, or XXX-XXX-XXXX.

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator at dapaxton@ncsu.edu or by phone at 1-919-515-4514.

Consent To Participate
I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may choose not to participate or to stop participating at any time without penalty or loss of benefits to which I am otherwise entitled.”

Subject's signature_______________________________________ Date _________________
Investigator's signature__________________________________ Date _________________
Appendix C: Surveys & Questionnaire

Demographics Questionnaire

1. What is your race/ethnicity?
   a. African American/Black
   b. White/Caucasian
   c. Hispanic/Latino
   d. Asian/Pacific Islander
   e. Native American
   f. Other

2. What is your gender?
   a. Male
   b. Female

3. What is your age? _____

4. What is your major area of study (i.e. biology, chemistry, etc.)?
   ______________________________

5. Are there any scientists or science majors in your family?
   a. Yes
   b. No
6. What is your academic classification?
   a. Freshman
   b. Sophomore
   c. Junior
   d. Senior
   e. Graduate Student
   f. Professional student

7. What is your current enrollment status?
   a. Full-time
   b. Part-time

8. What is the name of the HBCU that you attend? _____________________

9. How many science courses did you take in high school?
   a. None
   b. 1-2
   c. 3-4
   d. 4-6
   e. more than 6
10. What is the highest-level science course taken in high school? ____________________

11. Did you take any honors or Advanced Placement/International Baccalaureate science courses in high school?
   a. Yes (If yes, how many?)
   b. No

12. How many mathematics courses did you take in high school?
   a. None
   b. 1-2
   c. 3-4
   d. 4-6
   e. more than 6

13. What is the highest-level mathematics course taken in high school? __________________

14. Did you take any honors or Advanced Placement/International Baccalaureate mathematics courses in high school?
   a. Yes (If yes, how many?)
   b. No

15. Did you participate in any science camps, programs, or clubs when you were in high school?
   a. Yes (If yes, how many?) ________
   b. No

16. What was your high school grade point average? (Make a close estimate) ______
17. What was your mathematics SAT or ACT score? (Make a close estimate) ________
18. How many college science courses have you taken? _____
19. How many college mathematics courses have you taken? _______
20. What is your cumulative college grade point average? (Make a close estimate) ________
21. What is your college SCIENCE grade point average? (Make a close estimate that includes grades from all Biology, Chemistry, and Physics courses) __________
22. Have you participated in any summer science-related programs or internships?
   a. Yes (If yes, how many?) __________
   b. No

Survey Questions

Identity as a Scientist

Prompt: “The following questions ask how you think about yourself and your personal identity. We want to understand how much you think that being a scientist is part of who you are.” Indicate the extent to which you agree or disagree with the following statements:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>In general, being a scientist is an important part of my self-image.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Being a scientist is an important reflection of who I am.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
3. I feel like I belong in the field of science.

4. I have a strong sense of belonging to the community of scientists.

5. I am a scientist.

Multidimensional Inventory of Black Identity (MIBI)

1. Overall, being Black has very little to do with how I feel about myself.

2. Blacks who espouse separatism are as racist as White people who also espouse separatism.

3. Being Black is not a major factor in my social relationships.

4. A sign of progress is that Blacks are in the mainstream of America more than ever before.

5. Being Black is an important reflection of who I am.

6. I have a strong attachment to other Black people.

7. Because America is predominantly White, it is important that Blacks go to White schools that they can gain experience interacting with White.

8. I have a strong sense of belonging to Black people.

9. In general, being Black is an important part of my self-image.
10. Blacks should strive to be full members of the American political system.

11. Being Black is unimportant to my sense of what kind of person I am.

12. My destiny is tied to the destiny of other Black people.

13. It is important for Black people to surround their children with Black art, music, and literature.

14. Blacks should try to work within the system to achieve their political and economic goals.

15. Black people should not marry interracially.

16. Blacks should strive to integrate all institutions which are segregated.

17. Blacks would be better off if they adopted Afrocentric values.

18. Blacks should feel free to interact socially with White people.

19. Black students are better off going to schools that are controlled and organized by Blacks.

20. Blacks should view themselves as being Americans first and foremost.

21. Black people must organize themselves into a separate Black political force.

22. The plight of Blacks in America will improve only when Blacks are in important positions within the system.

241
23. Whenever possible, Blacks should buy from other Black businesses.

24. A thorough knowledge of Black history is very important for Blacks today.

25. Blacks and Whites can never live in true harmony because of racial differences.

26. White people can never be trusted where Blacks are concerned.

27. Overall, Blacks are considered good by others.

28. In general, others respect Black people.

29. Most people consider Blacks, on the average, to be more ineffective than other racial groups.

30. Blacks are not respected by the broader society.

31. In general, other groups view Blacks in a positive manner.

32. Society views Black people as an asset.

Science Self-Efficacy Questionnaire

The following questions contain statements about your confidence for learning science. For each question, think about the extent to which you agree with each statement. For each statement, select to letter that best represents the extent to which you agree with the statement about your science confidence:

A. If you TOTALLY AGREE with the statement.
B. If you are AGREE with the statement.
C. If you are UNDECIDED about the statement.
D. If you are DISAGREE with the statement.
E. If you are TOTALLY DISAGREE with the statement.
1. I am confident that I can learn science
2. I am confident that I can get a good grade in science.
3. I am confident that I could do college level work in science.
4. I have a lot of self-confidence when it comes to science.
5. I am not the type to do well in science.
6. It takes me a long time to catch on to new topics in science.
7. Even before I begin a new topic in science, I feel confident I’ll be able to understand it.
8. I think I have good skills and strategies to learn science.

(Final Page of the survey)

Thank you for participating in the survey.

If you would like to have your name entered in a drawing for a $25 gift card. Please go to the following site XXXXX.
Appendix D: Interview Recruitment Letter

To Whom It May Concern:

A dissertation study led by Angela M. White, a doctoral candidate at North Carolina State University, will investigate the relationships that exist between the racial identity, science identity, and science self-efficacy beliefs of African American students in science (i.e. Biology, Chemistry, and Physics) who attend historically Black colleges and universities. Moreover, this study will evaluate the impact each of these factors has on the academic performance/success of African American students in science. The study will assess the role HBCUs play in facilitating the development of African American science students’ racial identity, science identity, and science self-efficacy beliefs (i.e. confidence in your ability to complete science related tasks or courses), as well as the relationship between each of these factors. This study is important because it will inform the development of more targeted intervention, programs, and teaching practices that focus on the academic success of African American science majors at both HBCUs and predominantly White institutions.

The researcher invites you to participate in her dissertation study. You will be asked to participate in a brief interview about your personal and academic experiences. The interview is expected to take 45 minutes to an hour. The interviews will be conducted either face-to-face away from your university, via SKYPE, or by telephone. All face-to-face interviews will be at a neutral, agreed upon location.

I greatly appreciate your assistance in making this research study possible. After completing the interview, participants will be given a $10 giftcard redeemable at a major national retailer.

If you have any questions related to the study, please feel free to contact Angela White. She can be reached at amwhite@ncsu.edu or by telephone at XXX-XXX-XXXX.

Sincerely,

Angela M. White, PhD Candidate
North Carolina State University
Appendix E: Interview Consent Form
North Carolina State University INFORMED CONSENT FORM for RESEARCH
(Interviews)

Title of Study: Understanding the Relationships Between the Racial Identity, Science Identity, and Science Self-efficacy Beliefs of African American Students at HBCUs.

Principal Investigator: Angela M. White       Faculty Sponsor: Jessica DeCuir-Gunby, Ph.D

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of research studies is to gain a better understanding of a certain topic or issue. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.

What is the purpose of this study?
Science, technology, engineering, and mathematics (STEM) careers provide great financial stability and are expected to experience a boom within the job market; however, very few African Americans are entering into or persisting through these fields to experience these advantages. In order to help change the direction of a declining representation of African Americans in science disciplines, this study seeks to accomplish four critical goals. One aim of this study is to gain a deeper understanding the relationships between science identity, racial identity, and science self-efficacy beliefs of African American students attending HBCUs. This study also seeks to explore the extent to which these constructs influence the science achievement of African American students attending HBCUs. Third, the study will investigate the degree to which the pre-college experiences of African American students attending HBCUs influence science identity, racial identity, and science self-efficacy beliefs, and college science achievement. The last aim of this study is to gain a more detailed understanding of the ways the African American students’ perspectives of their experiences at HBCUs influence their science self-efficacy beliefs, science identity, and racial identity.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to participate in one interview with the researcher listed above. The interview will last between 45 to 60 minutes, and may be face-to-face, by phone, or by Skype. Your interview will be audio recorded so that I am able to fully capture your
There is very little risk associated with this study.

Benefits

As a participant you will gain a greater awareness of your racial identity, science identity, and science self-efficacy beliefs and possibly insight into how these factors impact your performance in science.

Confidentiality

The information in the study records will be kept confidential to the full extent allowed by law. Data will be stored securely on a password-protected computer and in a locked file cabinet, which is only accessible by the researcher listed above. No reference will be made in oral or written reports that could link you to the study.

Compensation

You will receive a $10 gift card for engaging in and completing the interview. If you withdraw from the study prior to its completion, you will not be eligible to receive the gift card.

What if you have questions about this study?

If you have questions at any time about the study or the procedures, you may contact the researcher, Angela M. White, at amwhite@ncsut.edu, or XXX-XXX-XXXX.

What if you have questions about your rights as a research participant?

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator at dapaxton@ncsu.edu or by phone at 1-919-515-4514.

Consent To Participate

“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may choose not to participate or to stop participating at any time without penalty or loss of benefits to which I am otherwise entitled.”

Subject's signature_______________________________________ Date _________________

Investigator's signature_______________________________________ Date _________________
Hello,

With your permission, I would like to interview you today about your experiences as a science major at a historically Black college and university, as well as the influences that have impacted your development as an African American science person. All of the information that we discuss in this interview will be kept confidential and your identity will not be revealed on any of the documentation related to this study. With your permission, I will audio-record our interview and take notes throughout our discussion. You may end the interview at any point and may choose to not answer any questions that make you feel uncomfortable. Do you have any questions before we proceed with the interview?

1. **Tell me about yourself.**
   a. Probe – Where are you from?
   b. Probe – Do you have siblings? Did they go to college? Are they in college?
   c. Probe – What is your academic background?
   d. Probe - What is your major?
   e. Probe – What is your classification?
   f. Probe - What is your grade point average?
   g. Probe – Discuss the demographic make-up of your high school

2. **Tell me about your decision to attend an HBCU.**
   a. Probe - Why did you choose to attend your HBCU?
   b. Probe – How would you describe your HBCU to another person?
   c. Probe - What is it about your HBCU that has shaped you for a career in a science-related field?
3. Tell me what it means to be African American to you.
   a. Probe: How important is it for you to be African American?

4. Tell me what it is like to be an African American student at an HBCU.
   a. Probe: Tell me about any key moments or major events that have shaped who you are as an African American.

5. Tell me about your decision to major in a science field.
   a. Probe: Why did you choose to major in _________ (the blank is for the student’s current major)?

6. Tell me what it means to be a scientist.
   a. Probe: Is it important for you to be recognized as a scientist? If yes, why?
   b. Probe: What is it like to be an African American in a science field?

7. Discuss a time when being African American positively influenced how you view yourself as a scientist.

8. Discuss a time when being African American negatively influenced how you view yourself as a scientist.

9. Tell me about your pre-college experiences as an African American in science (i.e. high school course-taking patterns and science programs/camps).

10. Tell me about your experiences as an African American in science at your HBCU.
    a. Probe: Tell me about any key moments at your HBCU that have shaped who you are as a science person.
    b. Probe: What do you think it would be like to be an African American in science at a predominantly White institution?
11. Discuss your confidence in your ability to successfully complete a biology course?
   a. Probe: What about a chemistry course?
   b. Probe: What about a physics course?

12. How has attending an HBCU influenced your confidence to conduct a scientific experiment?

13. Discuss your interactions with faculty, staff, and other students at your university.
   a. Probe: How do these interactions influence how you see yourself as an African American?
   b. Probe: How do these interactions influence how you see yourself as a scientist?

14. Is there anything else that you would like to share with me about your experience as an African American science person?

This concludes our interview. I would like to say thank you for the time you have taken out of your schedule to engage in this interview. I am confident that the information you provided will be very useful to my dissertation research.

Please feel free to contact me if you have any questions, comments, or concerns pertaining to this interview. Again, thank you for your participation and have a wonderful day!