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UNIQUE AND DIVERSE VOICES OF AFRICAN AMERICAN WOMEN IN ENGINEERING AT PREDOMINATELY WHITE INSTITUTIONS: UNPACKING INDIVIDUAL EXPERIENCES AND FACTORS SHAPING DEGREE COMPLETION

A Dissertation Presented

by

ELLISE M. DAVIS LAMOTTE

Submitted to the Office of Graduate Studies,
University of Massachusetts Boston,
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2016

Higher Education Administration Program

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ABSTRACT

UNIQUE AND DIVERSE VOICES OF AFRICAN AMERICAN WOMEN IN ENGINEERING AT PREDOMINATELY WHITE INSTITUTIONS: UNPACKING INDIVIDUAL EXPERIENCES AND FACTORS SHAPING DEGREE COMPLETION

May 2016

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Directed by Associate Professor Tara L. Parker

In 2012, 1% of the African American women who enrolled in an undergraduate engineering program four years prior graduated, amounting to 862 African American women graduating with engineering degrees. This qualitative study, anchored in interpretive phenomenological methodology, utilized undergraduate socialization with an overarching critical race theory lens to examine the manner in which African American women in engineering, such as the 862, make meaning of their experiences at predominately White institutions.

The findings of the study are important because they corroborated existing research findings and more importantly, the findings in this study emphasize the importance of faculty and institutional agent support, self-efficacy leading to motivation, academic achievement goals and the development of science identities. These factors were significant to the persistence of African American women in this study. Moreover, this study's findings suggest that these factors must work in concert to be most effective. The findings demonstrated that students need to develop relationships with faculty, administrators and peers. The administrators provide access to resources that assist with persistence and peers are needed for group work and academic support. The faculty relation is most important because the faculty members provide access to information, research opportunities, grades and research and industry contacts. The research also found that the women carried the responsibility of developing and nurturing the relation with the faculty.

Moreover, all of the African American women in the study acknowledge racism and sexism however, they responded to these deterrents differently. Some of the women were negatively affected while others chose to ignore the deterrents. However, with the presence of these obstacles, the study validated the notion that these African American women in engineering had a strong sense of self-efficacy which provided a foundation for the women to possess science identities: research scientist, altruistic or disruptive. With these identities, the African American women sought to engage their scientific knowledge further in graduate school, the workplace and altruistically to improve upon society.

These findings produce implications for policy and practice, suggesting that engineering colleges commit to transforming academic environments to reflect an atmosphere that is inclusive and supportive of racial and gender differences. This transformation should encompass pedagogy, curriculum, composition of faculty and student populations as well as the academic culture, allowing for a more welcoming and supportive atmosphere, where African American women can persist without concern for proving themselves because of their race or gender.

DEDICATION

For my mother Betty J. Davis and my father Ellis R. Davis Sr.
You sacrificed it all for me and Ellis and we are forever grateful.
For my husband Keith LaMotte
You are my rock: supportive, steady and loving
For my daughter Jasmine LaMotte
This is for you
I want you to know that you can do and be whatever you want to do or be
I love you all!

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The journey of pursuing my doctorate was one of the most challenging endeavors I have embarked upon and I could not have been successful without many individuals who have helped me along the way. First, I would like to thank God.

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I would like to thank my husband Keith A. LaMotte because he gave me the wings to soar and all the air and space to fly in. I would like to thank my daughter Jasmine E. LaMotte; because of her, I try to be a better person. I love you both!

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TABLE OF CONTENTS

CHAPTER Page

ABSTRACT iv

DEDICATION vii

ACKNOWLEDGEMENTS viii

LIST OF TABLES xiii

LIST OF FIGURES xiv

BACKGROUND 1
Problem Statement 6
Purpose Statement 11
Research Questions 13
Significance of Research Study 15
REVIEW OF THE LITERATURE 18
Diversity Concerns 18
Economic Concerns 21
Social Justice Concerns 27
Critical Race Theory 28
Socialization of Students in STEM Fields of Study 31
Undergraduate Socialization Model 31
Student Background 34
Parental Influence 34
Socio-Economics Status 36
High School Experience 38
Collegiate Experience 39
Interpersonal and Intrapersonal Interactions. 44
Institutional Agents. 46
Campus racial climate. 47
Microaggressions. 51
Stereotype threat. 53
Engineering Department Racial Climate. 54
The STEM academic environment and pedagogical practices. 56
Sense of belonging and self-efficacy. 61
Intervention activities – responses to negative racial campus climate 65
The Intersectionality of Race and Gender - The Double Bind. 69

CHAPTER Page

Science Identity ... 71
Aspirations, Career Choices, Life Values and Style Preferences . 73
Achievement Goal Theory ... 74
Summary of the Literature ... 78
Conceptual Framework Guiding this Study ... 80
Undergraduate Socialization and Critical Race Theory ... 83
RESEARCH METHODOLOGY ... 88
Researcher's Worldview ... 88
Researcher Role ... 89
Phenomenology Definition and Rationale ... 91
Hermeneutic Interpretive Phenomenology ... 92
Methods ... 95
Site Selection ... 95
Description of the Engineering Schools ... 97
Study Participant Selection ... 98
Participant Recruitment ... 99
Data Collection ... 100
Data Analysis ... 102
Trustworthiness ... 104
Conceptual Framework ... 106
Limitations ... 106
FINDINGS ... 108
Introduction of African American Women and their Voices ... 108
Introduction of Core Themes ... 119
In the Beginning - STEM Exposure ... 120
Motivation ... 137
Academic Achievement Goals ... 145
Learning Styles ... 153
FINDINGS ... 155
Institutional Support and Institutional Barriers ... 155
Sense of Belonging ... 161
Faculty Interaction ... 175
Student Interaction ... 188
Collaborative and Competitive Climates ... 205
Science Identity ... 209
Career Goals ... 215
Responses to Racism and Sexism ... 224
DISCUSSION AND CONCLUSION ... 230
Discussion ... 233
Self-Efficacy ... 234
Motivation ... 237
Faculty Interaction ... 239

CHAPTER Page

Student Interaction 241
Institutional Agents and Counterspaces 242
Systemic Racism and Sexism 244
Implications for Policy and Practice 246
Future Research 252
Conclusion 255
APPENDICES 258
A.INTRODUCTION SCRIPT – FACULTY AND ADMINISTRATORS 259
B. TEXT AND SCRIPT FOR STUDENT PARTICIPANTS 261
C. ELIGIBILITY CRITERIA PROTOCOL 264
D. GENERIC CONSENT FORM 266
E. CONSENT TO AUDIOTAPE & TRANSCRIBE 271
F. INTERVIEW PROTOCOL 273
REFERENCES 277

LIST OF TABLES

TABLE Page

1 Undergraduate Degrees Earned 6

2 Undergraduate Degrees Earned in 2012 Men and Women 7

3 Women Graduating from Undergraduate Engineering Degree 8

4 African American Women Graduates in Engineering Programs 2012..... 9

5 Median Salaries per Education Level 24

6 Intentions for Majors 2008..... 41

7 Bachelor's Degrees Awarded 2012 41

8 Participant Demographics 118

9 Core Themes and Sub-Themes 120

LIST OF FIGURES

FIGURE Page

Figure 1 Undergraduate Socialization Model 33

Figure 2 Undergraduate Socialization Model Modified to include Critical Race Theory 87

CHAPTER 1

BACKGROUND

African American women are significantly underrepresented in engineering fields, accounting for 25% of the total enrollment population in undergraduate programs, but only representing 1% of the undergraduate engineering graduating population (National Science Foundation [NSF], 2014). This underrepresentation of African American women graduates in engineering raises significant diversity, social justice and economic concerns that should be considered in order to determine reasons for their existence and to find the solutions needed to eliminate them. In the case of diversity, it is important to find ways in which to enhance it.

Diversity concerns are two-fold. First, diversity concerns focus on its effectiveness and its use as it pertains to groups of individuals working together to solve a problem. If correctly implemented, the collective performance of a diverse group can be used along with an individual's ability, allowing for more sophisticated solutions (Page, 2007). Second, diversity concerns can be viewed as a means to an end in which diversity is used to fill a void, like the perceived decrease in the science technology, engineering

and math (STEM) workforce, and not as a method to produce a social justice outcome. Social justice concerns differ from diversity concerns in this instance because the diversity concerns focus on the manner in which diversity can improve the performance of a group of individuals. It also emphasizes the ways in which increased diversity can be used to only fill a void. Social justice concerns focus on equity and the lack of minorities and women in higher education in general, and in STEM majors specifically, whereby not enough underrepresented student populations, like African American women, are entering in and/or graduating from STEM majors as compared to their White student counterparts (Chen & Carroll, 2005; Twigg, 2005). Race, gender and the intersectionality of the two should be considered in the social justice theme because there are systematic reasons as to why African American women are not better represented in the STEM environment.

The economic concerns focus on the workforce supply argument suggesting the need to grow the domestic STEM workforce by increasing underrepresented populations, (like African American women) in STEM related careers (such as engineering). Researchers still question the need to increase the STEM workforce as a whole. However, the focus on increasing underrepresented groups, like African American women, is not in question and is an important element in the creation of STEM education and STEM workforce environments that include diverse voices, experiences and solutions. To address these diversity, social justice and economic concerns, higher

education institutions need to transform learning environments to provide the necessary support to underrepresented students such as African American, Latino and women (Chairman's Staff of the Joint Economic Committee, 2012; Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2008). For example, Mayor (1998) stated that:

> It is now clear that, to fulfill its mission, higher education must change radically by becoming organically more flexible, and at the same time more diverse in its institutions, its structures, its curricula, and the nature and forms of its programs and delivery systems. (p. 2)

Dewey (1916:1966) also concluded that both shared learning experiences and understanding among all citizens are necessary for equitable education to occur and that without equitable education, "the influences which educate some into masters, educate others into slaves" (p. 84). Furthermore, this equitable act of shared learning and understanding is essential in allowing all citizens to participate actively in their own professional environment, thus fostering "democratic professionalism" (Dzur, 2008, p. 80). This democratic professionalism should include women; however, the National Research Council (1999) concludes that "our nation is being divided into a technologically knowledgeable elite and a disadvantaged majority" (p. 1), where women represent the disadvantaged majority. Instead, women should be included in the technological and scientific learning and knowledge-building (National Research

Council, 1999). Long and Fox (1995), Pearson and Fechter (1994), Sonnert, Fox and Adkins, (2007) and Press and Letter (2011) agree that underrepresentation of women and women of color in science and engineering fields is a significant loss for the United States (US) because it represents the loss of substantive and diverse contributions that women could lend to the field of science. According to Ong, Wright, Espinosa and Orfield (2011), "the benefits of equity and justice, in conjunction with our country's shifting demographics and national imperative to further scientific innovation and competitiveness, point to the growing importance of understanding, recruiting, and supporting women of color in STEM education" (p. 176).

The needed understanding, recruitment and support is required because studies suggest that underrepresented populations in STEM majors at selective predominately White institutions (PWIs) are less likely to persist to degree completion as compared to their counterparts at minority serving institutions (MSIs) like historically Black Colleges and Universities (HBCUs) (Diverse, 2006; Trent et. al, 2003), where students experience encouragement with more frequent interactions with faculty members, a more supportive environment and a student-centered environment (Allen, 1992; Hurtado, 2003; Hurtado et al., 2009; Nelson Laird et al., 2007; Eagan, Hurtado & Chang, 2010).

Brand, Glasson and Green (2006) studied African American students to better understand sociocultural factors that influence their achievement or lack thereof in science and mathematics classes at PWIs and concluded that "acts of exclusion are

concealed behind the representative symbols of science and mathematics" (p. 19), thereby hindering the persistence and degree attainment of African American students. These acts of exclusion discourage underrepresented students, like African American women, because these experiences make them feel as though they do not belong in the environment. These findings suggest that the acts of exclusion are important factors as they pertain to degree completion. These acts can be described as processes such as the weed-out process, whereby students are weeded out of engineering programs in the first year (Seymour & Hewitt, 1997) and lecture hall pedagogy, where information is presented to students in one direction, not allowing for a dialogic transference of information (Freire, 2000). Seymour and Hewitt (1997) examined these types of factors that cause undergraduate students to switch from science, mathematics and engineering (SME) majors into disciplines which are not SME-centered and conclude that underrepresented students of color and women have a more difficult time persisting and reaching degree attainment in undergraduate science majors as compared to White men, despite academic preparedness, due to these systemic academic obstacles. For African American students, various themes emerged pertaining to challenges they faced in STEM academic environments such as differences in socialization and cultural values, stereotype threat, feelings of isolation, racism and the absence of programmatic support. These topics contribute to experiences and challenges of African American students in STEM-related majors (Seymour & Hewitt, 1997).

Problem Statement

Examining African American women in engineering who persist would be an effective method to better understand, recruit and support this population. This examination will provide an asset-based approach rather than a deficit-based approach that focuses solely on the underrepresentation. This approach will emphasize the capabilities and resources these women possess and use to persist. With this awareness, I have concluded that the experiences of African American women in engineering, as they persist academically, are a critical area of study to examine. This focus allows for a better understanding of their academic success and associated influential factors. To fully understand the experience of African American women in engineering and to identify existing support structures and/or barriers to persistence and degree completion, it is important to examine the educational environment in which they participate and the manner in which they experience it.

In 2012, 1.75 million students graduated with an undergraduate college degree in the US. Science degrees awarded represented 27.9% of the total degrees earned as compared to a 67.7% representation of degrees earned in non-science and non-engineering and a 4.4% representation of engineering degrees earned (Table 1).

Table 1 Undergraduate Degrees Earned

Science Degrees	27.90%
Non-science/Non-Engineering	67.70%
Engineering	4.40%

Of the 1.75 million college graduates in 2012, 60.83% of the non-science and non-engineering graduates were women. Additionally, women graduating from science programs represented 55.82% of the total graduates and women graduating from engineering programs accounted for 19.08% of the total graduates.

In comparison, men graduating from the non-science and non-engineering programs represented 39.17% of the total graduates. Furthermore, men graduating with science degrees accounted for 44.18 % of the total graduates and men graduating from engineering programs represented 80.92% of the total graduates (Table 2).

Table 2 Undergraduate Degrees Earned in 2012 Men and Women

Undergraduate Degrees Earned in 2012 - Men and Women		
	Women	Men
Non-Engineering/Non-Science	60,83%	39.17%
Science	55.82%	44.18%
Engineering	19.08%	80.92%

Significant to this study is the representation of women and men graduating from engineering programs as compared to all graduates, 1% and 4% respectively. These percentages uncover a significant difference between the representation and persistence of men and women graduating from engineering majors.

When examining the representation of women in college, one can posit there to be a disproportionate percentage of women participating in engineering programs as compared to this population's overall participation in higher education (National Science Foundation, 2014). In 2012, 83,263 students graduated with an engineering degree and

19.08% were women. Of those graduating in engineering, 11% were White, 3% were Asian, 2% were Hispanic, less than 1% were Native Americans, 2.7% were women who identified as other and African American women represented 1%, which amounts to only 862 out of 83,263 engineering graduates in the US (Table 3).

Table 3 Women Graduating from Undergraduate Engineering Degree

Race/Ethnicity	
White	11%
Asian	3%
Hispanic	2%
Native American	>1%
Other	2.70%
African American	1%
Temporary resident	1.5%

Moreover, all engineering disciplines are not created equal in that there are specific majors where African American women persist more than others. For example, in 2012, 193 African American women graduated from electrical engineering programs, 161 African American women graduated from other engineering programs 146 graduated from civil engineering programs, 139 African American women graduated from chemical engineering programs, 78 from industrial engineering programs, 15 African American women graduated from aerospace engineering, and 4 African American women graduated from materials engineering programs (Table 4). Further examination is required to determine if there are specific nuances related to different engineering majors and how these variances affect intention and persistence.

Table 4 African American Women Graduates in Engineering Programs 2012

Electrical Engineering	193
Other	161
Civil Engineering	146
Chemical Engineering	139
Industrial Engineering	78
Aerospace Engineering	15
Material Science Engineering	4

Researchers agree that underrepresentation of women and women of color in STEM majors, like engineering, can be attributed to higher education institutions' failure to develop and support women and students of color (Carlone & Johnson, 2007; Hanson, 1996, 2004; Justin-Johnson, 2004; Ong, 2005). This underrepresentation is more evident for aspirants attending selective four-year PWI as compared to less selective PWIs (Chang et al., 2010). Eagan (2009) studied STEM undergraduate degree completion rates and discovered that selective PWIs were more effective than their less selective counterparts at producing STEM undergraduate degree recipients. Reasoning for these comparisons suggest that a more academically successful student pool entering into the STEM pipeline is a significant contributor to more STEM degree completions. Additionally, evidence exists concluding that African American students in STEM programs enjoy their experiences at a higher rate when they attend an HBCU versus a PWI. The HBCU graduates have a higher propensity to participate in STEM graduate work, and to continue on to receive STEM terminal degrees (W. Pearson & Pearson, 1985; Solórzano, 1995; Suitts, 2003). A possible explanation of this phenomenon is the

conclusion that students attending HBCUs encounter an environment that is nurturing and supportive resulting in more academic self-efficacy, outcome expectations, technical interest and support as compared to their African American counterparts studying at PWIs who do not experience a nurturing or supportive environment (Lent et al., 2005).

African American students, as well as others who are underrepresented, enter college in pursuit of a STEM degree at the same rates as their White counterparts (Anderson & Kim, 2006; Elliot, Strenta, Adair, Matier, & Scoot, 1996; Tyson, Lee, Borman & Hanson, 2007); however, underrepresented populations, like African American women, are more likely to transfer out into non-STEM majors, thus decreasing their persistence in STEM majors as compared to their White counterparts (Chubin & Babco, 2003; Culotta, 1992; Elliot et al., 1996; Georges, 1999; Morrison & Williams, 1993). A common misconception states that traditionally underrepresented populations, like African American students, are not academically prepared to persist through the first year of an engineering program (Anderson & Kim, 2006; Schuman, Steeh, Bobo & Krysan, 1997). Cabrera, Nora, Terenzini, Pascarella, and Hagedorn (1999) disagree with this notion and conclude there to be no support to corroborate the claim that academic preparedness hinders the persistence of African American college students as compared to their White counterparts. Rather, a significant influence on persistence and degree completion of African American students in engineering is the academic environment they experience, like the classroom, and interaction with faculty and peers.

In 2012 862 African American women graduated with an engineering degree as compared to the 6,098 African American women who entered an engineering program in 2006. This significant decrease in the number of African American women who graduated in engineering in 2012 demonstrates the lack of support and understanding as well as chilly and unwelcoming climates these women are confronted with (NSF, 2006). Given the challenges these women face, the statistics warrant further investigation and raise the question as to how this population of 862 African American women successfully persisted to degree completion and how they experienced and interpreted their accomplishments (NSF, 2013). This question is the focus of my research study.

Purpose Statement

The purpose of my qualitative phenomenological research study is to examine, understand and interpret the manner in which African American women experience and find meaning as they persist toward degree completion in an engineering academic environment (Maxwell, 2005; Patton, 2002). The study is grounded in social constructivism, and allowed me to construct meaning from the experiences of African American women in engineering programs through open-ended dialog and the interpretation of experiences. Social constructivism can be defined as an individual's reality that is "made known, reinforced, and changed by members of society" (Newman, 2000, p. 49). This understanding is important because these women's experiences are

being made known, reinforced and changed by faculty, peers and institutional agents. Along with social construction, Critical Race Theory (CRT) is used as the overarching framework to highlight the "unique voice of color" (Delgado & Stefanic, 2001, p. 9) and for this study these unique voices will belong to African American women in engineering. With this understanding, I will examine the engineering academic experience to recognize how African American women make meaning of it.

I selected the experience within the academic environment as the phenomenon because this environment is often challenging for women and women of color. These challenges manifest from a departmental climate that supports competition, contains unapproachable faculty members and utilizes the weed-out process, whereby faculty examine students' ability and character, deciding on the students who are deemed worthy to persist. For women and people of color, this worthiness is not easily or often bestowed (Seymour & Hewitt, 1997). In contrast, the academic environment could be supportive and learning-centered where the "purpose is not to transfer knowledge but to create environments and experiences that bring students to discover and construct knowledge for themselves, to make students members of communities of learners that make discoveries and solve problems" (Barr & Tagg, 1995, p. 15).

Research Questions

My research study seeks to explore the following overarching research questions:

1. How do successful African American women in engineering experience and make meaning of their academic environment?
2. How do successful African American women in engineering respond to their experiences in the academic environment to further their persistence?
3. How do successful African American women make meaning of their relationship with faculty and peers?

For the purposes of this study and the research questions, successful African American women in engineering are defined as individuals who persist toward degree completion per their academic institution's requirements. Additional research focusing on persistence of African American women in engineering, despite the environment in which they learn, is needed such that researchers, administrators and faculty can better understand how this population succeeds in engineering academic environments which have traditionally been chilling and unwelcoming. Previous research does not focus specifically on African American women in engineering majors and this research gap could skew specific conclusions because this group would be viewed as a component of a larger population, thus conclusions would not pertain specifically to African American women. Moreover, there is no significant research delineating STEM majors to determine the differences and nuances present for students, particularly, students of color, women of

color and African American women, specifically. Many studies presented focus on STEM majors as a group and do not take into consideration the specificity of majors within STEM. A more focused and delineated research approach would enable administrators and faculty members within higher education institutions to better understand and educate a more diverse student body. Keeping the focus on African American women, as opposed to the entire group of women, will provide information and conclusions that are specific to this subset, and this specificity will render these students and their experiences as viable evidence. These distinctions are important because "women in engineering do not necessarily share common experiences of marginality" (Lord et al., 2009, p. 170).

These research gaps are important to fill because African American women have been underrepresented in STEM and are now being targeted, by the US government through organizations like the NSF, National Institute of Health (NIH), corporations and some higher educational institutions to participate in STEM education and the STEM workforce. This emphasis on successful experiences of African American women in engineering could be used to increase the number of African American women entering and graduating from engineering majors, and thus assist in filling the need for a larger more diverse STEM-educated workforce in the US as well as improving educational equity. My study pertaining to African American women, their experiences and success would also provide critical information to engineering departments in higher education

institutions. This information would help to improve representation, persistence and degree completion rates of African American women in engineering, ultimately increasing the STEM workforce.

Despite numerous barriers, 1% of African American women successfully completed degrees in engineering in 2012, equaling 862 African American women. How did these women persist and how did they make meaning of their success? With this notion, my study will address the experiences of African American women as they successfully persisted toward degree completion in an undergraduate engineering degree. For the purposes of this study, success represents the attainment of a junior or senior status in an engineering program as per the graduation timeline and guidelines of the institution.

Significance of Research Study

There are specific stakeholders who would benefit from this type of study and would recognize its findings as significant to their own work. These stakeholders are US policy makers, industry leaders, fellow researchers and higher education administrators and faculty members interested in engineering education.

Federal and state policymakers like the President, Congress and Governors, who are interested in STEM education could benefit from my study because they are concerned about the decline in STEM-educated individuals in the US and are working

toward solutions to include more underrepresented populations like women of color into STEM education and thus STEM careers, allowing the US to strengthen its STEM presence in the global environment (Action Council for Minorities in Engineering, 2008; American Council on Education, 2006; Committee on Prospering in the Global Economy of the 21st Century, 2007; Espinosa, 2009). National organizations such as the NSF and NIH are also examining this concern and are committing substantial research funding focused on increasing underrepresented populations in STEM education and careers. For example, the NIH has commissioned a Diversity in the Biomedical Research Workforce work group with a mission to "provide concrete recommendations to the NIH Director on ways to improve the retention of underrepresented minorities, persons with disabilities, and persons from disadvantaged backgrounds through these critical periods" (NIH, 2011). These types of commitments underpin the need to increase production of domestic STEM workers in the US. (Committee on Equal Opportunities in Science and Engineering, 2004; National Science Foundation, 2006; Southern Education Foundation, 2005).

The conclusions of my study may also be used as scaffolding to develop better insight into the success of African American women in engineering majors. For example, researchers, higher education institution administrators and faculty could develop and implement tools and pedagogy enabling more African American women in engineering majors to persist, graduate and enter the STEM professional workforce (Corbett, Hill, &

Rose, 2010). Researchers could expand on my research focus, providing additional information resulting in a framework that is specific to African American women in engineering. Higher education institution administrators could use the findings of this study to evaluate how African American women are experiencing their successful persistence in engineering majors and make changes to improve their experience. Finally, engineering faculty members could evaluate their own pedagogy and curricula to determine how these factors could enhance the experiences of African American women in engineering.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter begins with reviews of pertinent research regarding three noteworthy bodies of literature. Diversity, social justice and economic concerns affecting underrepresented African American women in engineering will be reviewed because they address overarching matters regarding African American women in engineering. Finally, CRT and the Undergraduate Socialization model will be discussed and will be used as the study's conceptual framework.

Diversity Concerns

Diversity can be viewed through a social justice lens, where equity and inclusion of diverse voices and perspectives are used to solve problems (Page, 2007). It can be viewed as an interest convergence strategy whereby economic needs are being filled while the interests of the excluded groups are addressed and the act of inclusion is viewed as equitable justice (Delgado & Stefancic, 2001). One could also argue that this shift to increase diversity in the STEM workforce is representative of the CRT tenant suggesting interest convergence. This argument is warranted because the US as well as US

companies are now focused on increasing underrepresented racial and ethnic individuals into fields that were traditionally not open to them, such as STEM, due to a perceived shortage of STEM-trained workers. These efforts are now more prevalent because the US wants to keep pace with the rest of the world, as it pertains to the technological workforce (The 2015 Budget: Science, Technology and Innovation for Opportunity and Growth, 2014).

Diversity concerns are now considered to be a necessity, by US federal agencies and companies, as the US's population becomes more diverse. This change in demographics is causing companies and the US government and its agencies to re-define diversity as an asset to problem solving and a business growth tool and a business requirement in areas like engineering. This shift is caused by the need for a workforce that is comfortable and accepted in a variety of culturally diverse experiences. The shift toward diversity has also occurred to provide access to a comprehensive range of diverse perspectives that can enhance engineering design for problem resolution and product development (Busch-Vishniac & Jarosz (2004). Increasing the number of underrepresented groups, like African American women, would increase the diverse voices contributing to the problem solving needs. With this notion, it is important to unpack diversity to obtain a better understanding as to its importance to African American women's academic experience in an engineering environment.

According to Page (2007), there are four diversity concepts that warrant acknowledgement: Diverse perspectives, interpretations, heuristics and predictive models. Diverse perspectives are considered to be solutions to problems that arise from individuals who have different experiences and unique worldviews, resulting in varying solutions to problems. Diverse interpretations emphasize the way in which individuals categorize and classify "events, outcomes and situations" (p. 8). Diverse heuristics are tools used to solve problems. An example of this would be a common practice used to develop a solution. These heuristics are generally used in conjunction with a specific perspective. The final diverse concept is the predictive model describing relationships between objects or events and is used to help make sense of the environment. These concepts are important because they explain the manner in which diversity can be used to enhance environments like an engineering academic atmosphere.

The purposeful act of utilizing diversity allows a science or engineering professor to be more competent (Keith et al., 2003). Increased diverse perspectives will create different ways in which to solve complex problems through connections made with multiple perspectives. All in all "diversity trumps homogeneity: collections of people with diverse perspectives and heuristics outperform collections of people who rely on homogeneous perspectives and heuristics" (Page, 2007, p. 10). This notion is important because it provides a tangible use for diversity in higher education and in the workforce. Chubin, May and Babco, (2005) and Wulf (1998) agree with Page (2007), suggesting that

diversification of the engineering workforce should be considered a strength that produces an environment that makes teams more innovative, solutions more practical, products more functional and citizens more well-informed.

Economic Concerns

The economic perspective is another investigatory lens used to examine the underrepresentation of women and women of color in STEM majors such as engineering. However, there are two arguments associated with this perspective focused on the STEM environment. The first suggests that the US has a shortage of STEM educated individuals and needs to galvanize itself around efforts of developing a more robust STEM-educated workforce, starting from K-12 through the doctorate level and onto employment. This is described as the STEM workforce supply argument, suggesting that the US does not have enough supply of domestic STEM-educated individuals. Even though the US has produced STEM professionals who have developed substantial scientific advancements over the years due to education and significant innovations in STEM research (Casey, 2012), the US has relied on the education of individuals from other countries and has not taken the opportunity to educate more of its citizens to bolster its scientific and technological superiority (Anderson & Kim, 2005). To further the point, President Barack Obama stated that “we know that the nation that goes all-in on innovation today will own the global economy tomorrow. This is an edge America cannot surrender” (The 2015

Budget: Science, Technology and Innovation for Opportunity and Growth, 2014). More recently, global competition for STEM-educated professionals has grown, causing the US to rethink its strategy on increasing participation in STEM education as well as increasing the populations that receive this education. Currently, the US is losing its importance in the global marketplace due to the decline in STEM trained and educated individuals. Ultimately, the US needs to increase its production of domestic STEM workers in order to compete successfully on the global scale (Committee on Equal Opportunities in Science and Engineering, 2004; NSF, 2006; Southern Education Foundation, 2005). It is apparent that STEM educational and workforce environments are not taking full advantage of the potential talent available because women and women of color in particular, are still largely underrepresented in this field (Augustine, 2005; Committee on Equal Opportunities in Science and Engineering, 2012; Hrabowski, 2012; Sax & Shapiro, 2011).

Due to the increased need for engineering professionals, specifically in the US, industry leaders are developing efforts to attract more people of color (Chubin, May, & Babco, 2005). These actions are required because an increase in underrepresented populations, such as women of color, could assist the US in becoming more competitive in the global environment contributing to the number of STEM trained US citizens who could contribute to the STEM economy. This increase of underrepresented populations in STEM could also increase STEM industry development and thus provide diverse

solutions to domestic and global challenges (American Council on Education, 2006; Committee on Prospering in the Global Economy of the 21st Century, 2007; National Action Council for Minorities in Engineering, 2008). After studying the trends both in the US and abroad, the Committee on Prospering in the Global Economy of the 21st Century (2007) "is deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength" (p. 3).

What is more, women and women of color are losing economic opportunities and independence as it pertains to the STEM workforce because many are not participating in or graduating from STEM programs (Bystydzienski & Bird, 2006), which in turn, could impede their involvement in the STEM economy (Weinman & Cain, 1999). One plan of action is to strengthen domestic STEM participation by increasing the inclusion of underrepresented populations into higher education STEM majors. This is an important viewpoint due to the population growth of people of color, who represent 37% of the US population and whose growth will increase to 57% in 2060 (US Census Bureau, 2012). The increased participation, improved persistence and successful representation of people of color in STEM-related fields also have critical implications for their financial welfare (Baum & Payea, 2005; Carnevale & Desrochers, 2003; Choy & Li, 2005; Kelly, 2005). According to the National Center for Education Statistics (2015) 23% of African Americans between 25 and 29 years old have completed a four year undergraduate

degree and these statistics directly impact workforce salaries. As an example, the median salary is $29,950 for a high school graduate, $44,970 for a college graduate and $67,844 for a college graduate who graduates with an engineering degree (Institute of Education Sciences, 2012; Payscale, 2013); demonstrating the importance of increasing representation of underrepresented groups in STEM education (Table 5). This increased representation will enable these groups and the individuals within the groups to become more financially secure, independent.

In turn, this financial security will be significant for the African American community. The African American community faces challenges due to startling economic inequities. In most of the important indices of economic security, African Americans continue to trail the White population. An African American household has a median income of $34,600, which is $24,000 less than the median income of White households (Maloney, 2015). However, this gap would decrease if more African American women persisted in engineering majors and secured engineering careers because they could potentially impact these economic inequalities.

Table 5 Median Salaries per Education Level

Education Level	Salary
High School Diploma	$29,950
Non Engineering Undergraduate Degree	44,970
Engineering Undergraduate Degree	67,844

Conversely, opposing arguments conclude that there is no supply shortage. This notion manifests from the position that demand needed to support increased supply for additional STEM trained workers does not exist. Due to lack of demand, some researchers view demand-side market forces as the cause for pushing qualified students to pursue careers that are not STEM-related (Lowell & Salzman, 2007). If the increase of STEM trained workers continues, then the STEM workforce environment will become saturated; fewer trained STEM workers will find STEM related work; there will be a decrease in STEM salaries; and the US technology sector will be damaged whereby future college students could be discouraged from enrolling in STEM majors (Lynn & Salzman, 2011). More specifically, the US domestic economy and global competitiveness are facing challenges, but Lynn and Salzman, (2011) argue that the problem is not due to the shortage of trained engineers. Presently, there is no need requiring an increase of engineers in the US, nor is there a global threat, pertaining to a shortage of STEM educated workers. Countries like China and India are producing a substantial amount of engineers because they have significant infrastructure needs due to urbanization, such as road creation, bridge creation and manufacturing, and these projects require engineers (Lynn & Salzman, 2011).

Studies focused on the US STEM workforce have mainly focused on the supply side concluding that a STEM workforce shortage exists based on the “pipeline model” developed by NSF. This model was developed to make long term projections and policy

recommendations due to potential international technological competition (Lucena, 2005; Metcalf, 2007). The pipeline model has been used to forecast STEM workforce shortages and to focus on populations other than White men due to claims that White men were not going to enroll in STEM majors at the same rate as the past. Due to this conclusion, underrepresented populations, like women and minorities, were sought after to fill the potential void in the pipeline. However, within the pipeline model, researchers observe leaks in the pipeline due to individuals who do not exit the pipeline at the designated point, namely graduation. An example of this leakage is the transition between high school and college, especially for women and minorities (Blickenstaff, 2005; Blum, 2006; Camp, 2002; Kuck, 2001; Metcalf, 2007), and this brings focus back to the social justice concern of equity in STEM fields.

Counterarguments exist as to the real need for additional STEM workers due to the already overabundance of STEM workers presently. However, NSF (2015) data in Table 1 and Table 2 demonstrates that there is not an overabundance of underrepresented populations, particularly African American women in STEM fields, engineering in particular. The US government made a commitment more than 30 years ago to achieve educational equity between African Americans and Whites (Miller, 1999) and upon reviewing the most recent NSF data (2015) in Table 1 and Table 2, it can be determined that the goal has not been attained.

Social Justice Concerns

It is important for underrepresented students, like African American women, to participate in STEM education regardless of the argument purporting an overabundance of STEM educated individuals. Equity issues are apparent when disparity of underrepresented groups in STEM education is examined because these people are not able to take advantage of the benefits a STEM education can offer. The participation of underrepresented groups, like African American women, has increased over the past few decades in STEM education and workforce, but gaps are still evident (Huang, Taddeuse, Walter, & Samuel, 2000).

A STEM education can be used as a foundation for other careers and other educational paths. Individuals who study STEM majors are taught to think critically as well as how to be detail oriented; these skills and others can be used for career aspirations and growth (Scott, 2008). This spillover effect from STEM focused careers to other careers can present unique opportunities and enable graduates to obtain better salaries and more responsibilities (Langdon, McKittrick, Beede, Khan & Doms, 2011). Table 1and Table 2 illustrate the disparity in engineering participation, both in education and in the workforce, when comparing representation of women compared to men and non-White women compared to men. For example, there are only 862 African American women engineering graduates in 2012 compared to other groups (Table 1). Moreover, there are disparities in graduation rates when the subfields within engineering are analyzed (Table

3). In 2013, 472,000 African American women were classified as scientists while 5,000 of the scientists were also classified as engineers (Table 2). These diversity, economic and social justice concerns are reasons to investigate the underrepresentation of African American women in engineering.

African American women in engineering programs as they persist towards degree completion in an academic environment are the focus of this study. To frame the study, this chapter will continue reviewing the literature on women in STEM and engineering through the lens of undergraduate socialization. Socialization is "the process by which persons acquire the knowledge, skills and dispositions that make them more or less effective members of their society" (Brim, 1966, p. 3) However, this notion is socially constructed and has been created to benefit the White people, requiring non-White people to conform in order to be successful. Thus, it is important to include realities, lived experiences and methods by which students of color navigate these experiences and CRT will be used to operationalize this notion.

Critical Race Theory

CRT is used to study the use of power as it pertains to race and racism (Delgado & Stefancic, 2001). Along with providing an understanding of an individual's social situation and the manner in which society has organized itself, CRT was developed to assist with transformation in both areas. To accomplish this, CRT consists of various

tenets that assist with this transformation. The first tenet is “racism is ordinary, not aberrational” (Delgado & Stefancic, 2001, p. 7) and this is experienced by individuals of color on a daily basis. According to Delgado (1995), the assumption of White supremacy is so well entrenched in legal, political and educational sectors that it is not recognized for what it really is. The racial inequality and discrimination that ensue in areas such as education are so pervasive that they do not interest or concern most White individuals. As a result of this disinterest, most inequality and discrimination is no longer viewed as such by the majority White population. However, opposing beliefs and feelings exist among the non-White populations due to their clear understanding of the construction of White supremacy (Taylor, 2009).

Another CRT tenet is that of interest convergence (Bell, 1980) whereby “the interests of Blacks in gaining racial equality have been accommodated only when they have converged with the interests of powerful Whites” (Taylor, 2009, p. 5). The interest to increase underrepresented populations in STEM, due to the shortage of STEM professionals, is a perfect example of this tenet. In this instance powerful Whites will tolerate the advances of others as long as advancements benefit the White population in some manner. With this notion, conflict between White and Black populations is inevitable and true progress will only occur with resistance (Taylor, 2009). The third tenet considers the importance of historical context. Systems like political, legal and educational environments are based on fact that White people have possession of certain

rights to capital and property. Without the historical context, the reasons for this racial reality will be lost. Julian Bond (1991) submits the notion that historical illiteracy existing in the US is “an astounding ignorance of out racist past” (p. 222), thus CRT uses the backdrop of history to ensure it continues to be a part of the dialog.

The fourth tenet focuses on the narrative and the “unique voices of color” (Delgado & Stefancic (p. 9, 2001). The minority status brings with it an assumed competence to speak about race and racism. This method of storytelling encourages individuals of color to recount their experiences with racism and to take into account their unique interpretations and then voice these interpretations to counter the narratives of the White population (Delgado & Stefancic, 2001). These narratives serve to negate the notion of merit and colorblindness (Taylor, 2009).

These four tenets, focused on racism is normal, interest convergence, the importance of historical context and the unique voices of color are important to this study because they are tools I used to explore the educational environments experienced by African American women in engineering and how these women interpret the environment and the undergraduate socialization process. Thus, all four of the CRT tenants are important and are most relevant to my study.

Socialization of Students in STEM Fields of Study

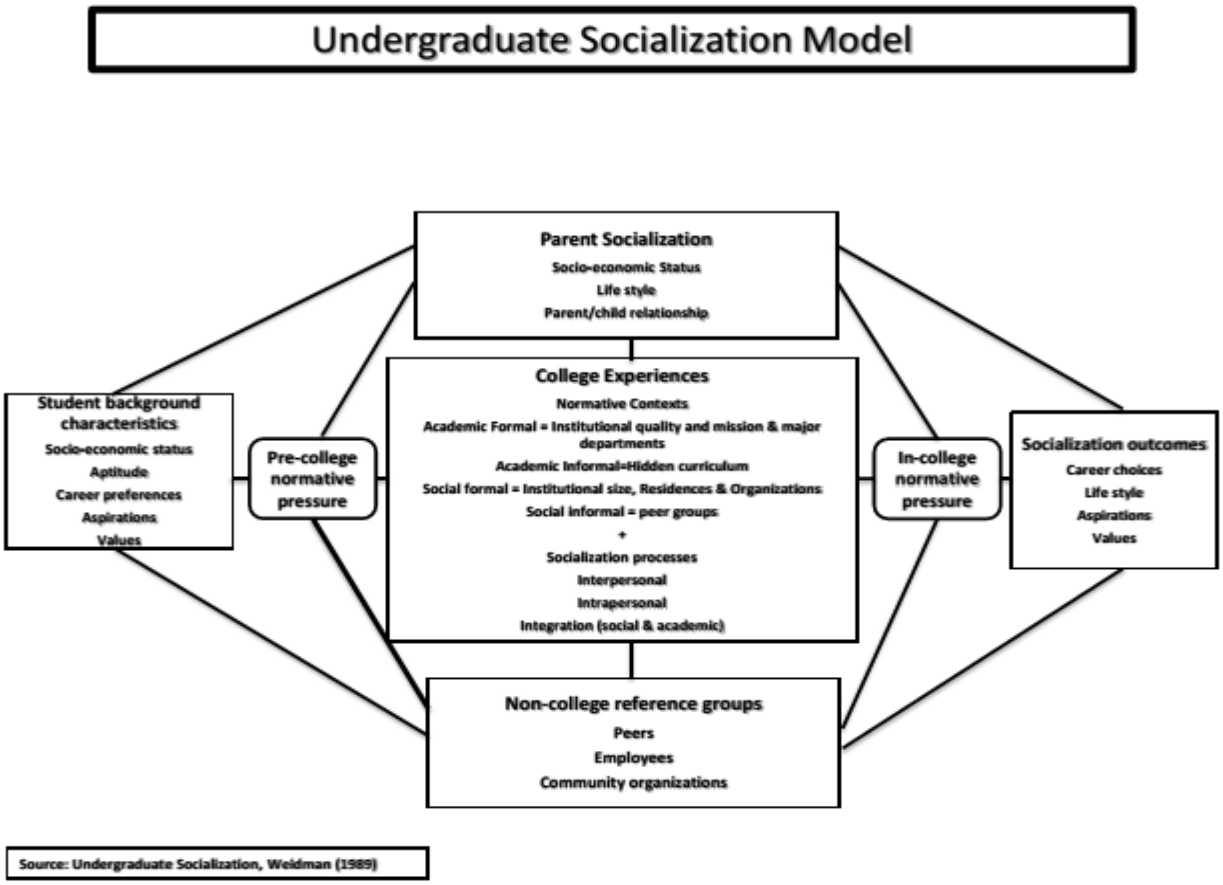
The college environment and student outcomes are the result of undergraduate socialization (Espinosa, 2009). This section of literature review will examine undergraduate socialization, focusing on parental involvement, socioeconomic status and the high school and college experiences. Some of the exploration will be more general and not always focused on African American girls or African American women specifically, due to the lack of delineation between racial groups on this topic in research literature. CRT is used as an overarching framework ensuring that the themes; racism as normal, interest convergence, and counter-story narrative are examined and are being heard within this discussion.

Undergraduate Socialization Model

The purpose of the undergraduate socialization model portion of the conceptual framework (Figure 1) is to provide a theoretical structure that summarizes the collegiate influence on students while taking the students' STEM interest, parent socialization, non-college reference groups and pre-college normative pressures into consideration (Weidman, 1989). Hurtado (2007) contends that Weidman's model of undergraduate socialization (1989) "stands alone in the field as the most comprehensive and explicit specification of social structure as normative contexts that shape student choices, lifestyle, preferences aspirations and values" (p. 99). According to Weidman (1989),

factors such as socio-economic status, aptitude, career preferences, aspirations and values that are associated with outcomes must be encompassed in any conceptualization of the undergraduate socialization process.

Figure 1 Undergraduate Socialization Model



Student Background

The environment in which individuals grow up is instrumental in shaping their background characteristics such as aptitude, career preferences, aspirations and values. However, due to the racial, ethnic and cultural differences that could be experienced at PWIs (Weidman, 1989), the student's background environment can also introduce challenges that could negatively impact African American students and their college adjustment and socialization at PWIs. These factors may hinder African American student degree completion (Carter, 2000; Cureton, 2003; Weidman, 1989).

Parental Influence

In anticipation of these challenges, many African American parents teach their children about their African American culture and heritage, supplying them with tools to combat any racism or discrimination they may face (Coard, Wallace, Stevenson, & Brotman, 2004; Hughes, 2003; Hughes et al., 2006; Hughes & Chen, 1997; Stevenson, 1995; Thomas & Speight, 1999). When focusing on families, Espinosa (2009) posits that encouragement from parents is a factor of academic attainment. However, Hurtado, et al., (2007) concludes that families can exhibit a positive and/or negative influence on minority students and on occasion can exhibit a negative influence on women of color who are majoring in STEM fields (Chowdury, S. & Chowdury, T., 2005; Valenzuela, 2006; Varma & Galindo-Sanchez, 2006).

As an example, women in STEM majors may be judged by their parents through historical stereotypes, suggesting that women should not pursue a technical major or career (Vetter, 1996). Vetter (1996) concluded that "as a group, parents have lower educational aspirations for daughters than for sons" (p. 32). This example can be described as stereotype threat whereas daughters fulfill the label of having low educational aspirations, thus potentially hindering their persistence as students in STEM majors because they will have to combat pressures associated with stereotypes presented by their parents (Seymour & Hewitt, 1997). This stereotype threat could also motivate women in engineering to excel in order to prove their parents and others wrong, thus demonstrating competence. All in all, parental socialization, negative or positive, can influence in-college pressures and socialization outcomes (Weidman, 1989). The combination of parental influences and the impact of other factors, such as socio-economics, values, aspirations aptitude and career preferences, from the student's background all assist in creating coping mechanisms students use when they encounter new college challenges. In fact, the parental role has been found to be influential in STEM fields of study and student persistence (Gayles & Ampaw, 2011). These pre-college influences and past experiences produce normative pressures that mold students' expectations and reactions to their new environment, especially when that environment reinforces information they may have heard growing up (Weidman, 1989).

Socio-Economics Status

Socio-economic status, a subset of the parental influence, constitutes the combination of the parent's educational accomplishment level, annual income and occupational esteem (Duncan, 1961; Duncan, Featherman, & Duncan, 1972; Sirin, 2005). The higher the parents' education level, the more involved they tend to be in their children's education, which in turn, translates into a positive impact on women as they enter and persist in the sciences (Astin & Sax, 1996; Huang, Taddese, & Walter, 2000; Maple & Stage, 1991; Rayman & Brett, 1995; Sirin, 2005). Maple and Stage (1991) explored factors that influence major selection in math and science to determine that a relationship exists for African American women between their major selection in math or science and the fact that their mothers have obtained a college degree (Heber, Kekelis, & Ancheta, 2005). This finding is more apparent for African American women versus White women and according to Heber, et al., 2005 and Litten (1982); parents' educational attainment is a significant factor in Black students' college selection. More specifically, family and parental influences are factors that play an integral role in STEM majors for these women of color pertaining to their interest and persistence (Andrade, 2007, Carlone & Johnson, 2007; Ellington, 2006; Russell & Atwater (2005), Sosnowski, 2002; Valenzuela, 2006). These parental influences are significant to students and their career preferences and goals, as they enter college (Bengston, 1975; Weidman, 1989; Winch & Gordon, 1974); however, there is a likelihood that this influence will decline in

senior year of college to the point where the relationship between parental influence and career selection will no longer be significant (Weidman, 1984). As stated by Weidman's model, these family members are considered to be members of the non-college reference group along with significant others like church members.

Researchers have also examined the influence of socioeconomics on educational persistence (Biblarz & Raftery, 1999; Ginther & Pollak, 2000; Leppel, Williams & Waldauer, 2001; Sandefur & Wells, 1999) and researchers concur with the notion that a high socioeconomic status can have a positive effect on students' educational attainment. Students originating from families with high socio-economic status will be more likely to select a major that will provide a more lucrative career (Green, 1992). Leppel et al. (2001) concluded there is a stronger likelihood for a woman to select an engineering major if her father is a professional or executive. This notion is corroborated in conclusions found by Betz & Fitzgerald (1987) and Ware, Steckler & Lesserman (1985) suggesting that a woman will more often select a male-dominated career if her father has attained high career levels. Along with this finding is the conclusion that there is a stronger effect for a woman when her father was in a profession or executive position versus if her mother was in a profession or executive position (Lepper et al., 2001).

High School Experience

Another background factor to consider is the high school experience. Women of color are faced with influences as they navigate high school, whether in a suburban environment, which is usually predominately White or in the inner-city, and these influences impact the major selected in college (Wilson, 2000). Research demonstrates that suburban environments may offer more advanced academic coursework as compared to inner-city high schools (Orfield & Lee, 2006); however, racial discrimination may also exist in suburban environments requiring navigation which could have a negative effect on African American women and their college major selection (Espinosa, 2009). As an example, Oakes (2005) found that teachers at predominately White high schools tend to track minority students, directing them away from advanced science and math classes, potentially leaving them ill-prepared for STEM college majors. These high school experiences, including teacher and administrator support, or lack thereof, is significant influences for women of color. For women of color (Chinn, 1999), these experiences play an important role in the decision to select and pursue a STEM major (Seymour & Hewitt, 1997). High school grades have also been considered influential in predicting STEM persistence for underrepresented minority students (Bonous-Hammarth, 2000) and for African American women the combination of test scores and high school GPAs has been a predictor of their success in college STEM majors (Carmichael, Brauer, Sevenair, Hunter & Garnbrell, 1986; Jones, Carmichael, Sevenair, & Hunter, 1986). Another

important high school factor is the selection and participation in math and science courses. According to Ellington (2006) and Russell & Atwater (2005), advanced and accelerated high school programs contribute to preparing women for STEM majors while also providing them with the self-confidence and needed academic skills to persist further in STEM majors. Participation in advanced programming will influence entry into a college as well as the intent to study a specific major (Anderson & Kim, 2006; Seymour & Hewitt, 1997), particularly for students persisting in STEM fields of study (Adelman, 2007).

Collegiate Experience

As students prepare for their collegiate experience, they may have intentions to study a specific major, only to change their educational direction midway through their academic journey. This is especially the case when students intend to study engineering and computer science majors versus the social and behavioral sciences major. For underrepresented populations, like African American women changing of academic direction is most evident (Griffith, 2010). In 2008, 180,755 African American women enrolled in college intending to study a STEM major, amounting to 32.4% of the total enrolled class at four-year institutions, as described in Table 4. Of the 32.4% of them 11.3% intended to study biology and agricultural sciences, 1.0% intended to study computer science, 2.6% intended to study engineering, .4% intended to math, statistics,

1.6% intended to study physical sciences and 15.4% intended to study social and behavior sciences. This percentage representation equates to 63,236 African American women intending to study biological/agriculture sciences, 5,596 African American women intending to study computer science, 14,550 African America women intending to study engineering, 2,238 African American women intending to study mathematics and statistics; 8,954 African American women intending to study physical sciences and 86,180 African American women intending to study social behavior sciences (Table 6). When comparing these figures of African American women graduating four years later, one will notice the number of African American women graduating is low compared to the intent four years earlier. STEM degree completions in 2012 consisted of the following: 5403 African American women graduates in biological/agricultural sciences, 1460 African American women graduates in computer science, 862 African American women in engineering, 465 African American women graduates in mathematics/ statistics, 798 African American women graduates in physical sciences and 12,260 African American women graduates in social behavioral sciences (Table 7) (NSF, 2014).

Table 6 Intentions for Majors 2008

	All S&E majors	Biological/ agricultural sciences	Computer sciences	Engineering	Mathematics /statistics	Physical sciences	Social/ behavioral sciences
All races	34.7	9.8	1.5	9.3	0.8	2.4	10.9
Women	29.5	10.4	0.4	3.1	0.7	2.1	12.8
Men	41.1	8.8	3	17	1	3.1	8.2
White	32.9	8.6	1.4	9.6	0.9	2.6	9.8
Women	24.5	8.3	0.3	2.3	0.7	1.8	11.1
Men	40.2	8	2.8	17.3	1	3.3	7.8
Asian	46.5	17.7	2	13.6	1	2.7	9.5
Women	40.6	20	0.5	5.5	0.8	2.3	11.5
Men	52.7	15.6	3.6	22	1.3	3	7.2
Black	32.7	9.8	2.4	6.1	0.4	1.5	12.5
Women	**32.3**	**11.3**	**1**	**2.6**	**0.4**	**1.6**	**15.4**
Men	33.4	7	4.4	11.8	0.5	1.7	8
Hispanic	38	10	1	9.1	0.9	1.4	15.6
Women	36.1	10.9	0.3	3	0.8	1.2	19.9
Men	41.2	9	2.2	18.1	1	1.6	9.3
American Indian	27.6	8	2	8.2	0	2.7	6.7
Women	22.7	8.6	1.6	2.6	0	3.1	6.8
Men	33.1	6.9	2.6	15.2	0	1.9	6.5

Table 7 Bachelor's Degrees Awarded 2012

	S&E	Biological/ Agricultural sciences	Computer sciences	Engineering	Mathematics and statistics	Physical sciences	Social sciences
Black Women							
(#)	31,581	5,403	1,460	862	465	798	12,260
(%)	5.60%	4.40%	3.20%	1.10%	2.60%	4.10%	7.20%

One could argue that there are other factors causing African American women to leave STEM programs, such as STEM academic environments, especially those in the sciences such as computer science, engineering and mathematics/statistics. Moreover,

there are engineering subfields that could have their own nuances, some proving to be more challenging than others. In 2012, 862 African American women graduated from an engineering program. Upon further review of the specific engineering majors, it is determined that Aerospace engineering graduated the least, at 15 graduates, and Electrical engineering graduated the most, at 193 graduates. There could potentially be reasons for these differences that could be explored further.

Research shows that academic preparation is a factor in the persistence of African American women in college STEM majors (Chang, Eagan, Lin, & Hurtado, 2009; Espinosa, 2009). However, research also demonstrates that African American students are as prepared as their White counterparts (Anderson & Kim, 2006; Elliot, Strenta, Adair, Matier, & Scoot, 1996) suggesting that college environments and climates serve to be more challenging for women and students of color (Brand, Glasson, and Green, 2006; Carlone & Johnson, 2007; Hanson, 1996, 2004; Justin-Johnson, 2004; Ong, 2005) and due to these challenging climates, rather than their academic preparedness, African American students transfer out of STEM majors and into less technical majors (Chubin & Babco, 2003; Culotta, 1992; Elliot et al., 1996; Georges, 1999).

According to Weidman (1989), socialization within the college experience develops into a number of outcomes where students' background characteristics tend to be factors. In my study, for example, background factors such as socio-economics, parental involvement, aptitude and values could help me obtain a clearer understanding

as to experiences had by African American women and their persistence in an engineering program.

Responses and outcomes, both negative and positive manifest from undergraduate socialization and are examined in the remainder of this chapter. Thus, the aim of my study will be to focus on the experiences had in the academic environment. With this focus, the remainder of this literature review will examine undergraduate socialization through the collegiate experience.

During college, students experience normative academic and social contexts. Academic normative contexts are developed through and by institutional settings which may include institutional mission and departmental priorities. This setting, created from the mission as well as faculty behavior, can lend to curriculum development, grading and academic guidance (Espinosa, 2009; Weidman, 1989). The social normative context is the result of campus extra-curricular activities and residential living arrangements. Normative academic and social contexts can present pressures, particularly for African American women in STEM majors like engineering. Due to the dominant presence of White men in STEM majors and their misconceptions of women and women of color (Hall & Sandler, 1984), these pressures can manifest as academic chilly climates or with the experience of microaggressions and feelings of isolation (Johnson, 2007).

Interpersonal and Intrapersonal Interactions. Within the college environment students also experience interpersonal interactions, intrapersonal interactions, and social and academic integration. The interpersonal interactions focus on relationships between faculty members and peers along with their strength and frequency. These student-to-faculty and student-to-student interactions are two significant socialization factors that have an impact on student development and learning (Cruce, Wolniak, Seifert, & Pascarella, 2006; Kuh & Hu, 2001; Pascarella & Terenzini, 1991, 2005; Tierney, Corwin, & Coylar, 2005). In particular, positive student-to-faculty interactions outside of the classroom provide an increase in academic and cognitive development (Terenzini, Pascarella, & Blimling, 1996), as well as in personal growth (Astin, 1993; Endo & Harpel, 1982; Pascarella & Terenzini, 2005), while improving the student's overall college experience (Kuh et al., 1990). Lundberg and Schreiner (2004) examined the impact of student-to-faculty interactions as it pertains to racial and ethnic populations and determined that this interaction contributes to learning and personal development for all racial and ethnic populations, particularly students of color.

While examining student-to-student interactions, Whitt, Edison, Pascarella, and Terenzini (1999) suggest that student-to-student interactions raise students' cognitive development, with further cognitive development occurring when the interactions are diverse (Dey, 1991; Pascarella & Terenzini, 2005). According to Astin (1984), students are also influenced by formal and informal environments where they interact with their

peers in student-to-student involvement. Throughout the socialization process, students are able to positively interact with one another and this interaction allows them to develop attachments to other individuals and the environment (Kuh, 1991; Zhao, Kuh, & Carini, 2005).

Intrapersonal interactions are the student's perception of their incorporation into the institution, department and classroom. During this time, students assess their environmental norms to determine normative influences on their specific circumstance and social context (Weidman, 1987; Wrong, 1961). For instance, an African American woman could perceive her academic environment to be inclusive and student-centered, and with this perception she makes the assessment that she can receive academic support in this environment. In describing the interpersonal, intrapersonal interaction and integration processes, Weidman (1989) stated that "the expectation is that the less favorable the student is in his or her perceptions of the college environment, the less likely that student is to be socialized toward the norms of the college" (p. 310). More specifically, negative socialization can occur for underrepresented students of color and women in the higher education academic environment, which, according to Weidman (1989), combines normative or standard contexts in the overall college socialization progression.

One study conducted by Colbert, Cabrera and Terenzini (2001) focused on classroom teaching practices and student learning in engineering majors. This research

found that the classroom environment cannot be ignored, corroborating previous research suggesting a direct, yet negative, relationship between college campus experiences and underrepresented students of color and women's self-efficacy while pursuing science, math, and engineering majors in environments with no support (Colbert et al., 2001). Johnson (2007) expands on this theme, concluding that negative socialization occurs in scientific curriculum and in STEM classrooms when individual characteristics like race and gender are deemed irrelevant to teaching and learning, causing underrepresented students of color and women to feel insignificant. With gender as the only consideration, women demonstrate lower levels of academic self-confidence as compared to men (Sax, 1994, 2008). This is also true when the academic abilities of men and women are equally matched (Sax, 1994, 2008). For women, this negative academic self-perception, and not their academic ability, is a significant factor causing their departure from STEM majors (Brainard & Carlin, 1998). Gender and its associated challenges, intersected with race, could account for additional barriers.

Institutional Agents. Family members have the ability to provide emotional support and encouragement, but they are not situated in a college setting and lack authority, thus would not be effective in providing the sense of belonging and validation required for students to succeed in a college setting (Rendón, 1993; Hurtado & Carter, 1997; Rendón, Jalomo, & Nora, 2000; Museus, Palmer, Davis, R. & Maramba, D. (2011). In contrast to

family, an important and positive socialization influence on a college campus is the existence of institutional agents.

The institutional agent is and individual who has power, status and control over resources in a hierarchic organization and uses his or her station to enable other individuals to obtain access to the resources and associated opportunities (Stanton-Salazar, 2011). These other individuals are those who have a lower social status, like African American women in an undergraduate engineering program. Research underscores the function of faculty, administrative and academic department leaders as well as student affairs professional in facilitating the access to college resources and success in college for students who have encountered economic injustice and/or racial discrimination (Bensimon, 2007; Bensimon & Dowd, 2009; Bensimon, Dowd, Alford, & Trapp, 2007; Cejda, Casparis, Rhodes, & Kelly, 2008; Museus & Neville, 2012; Teranishi & Briscoe, 2006) An important role of the institutional agents is to help students maneuver around the institutional bureaucracies, provide students with information about the college cultural and associated expectations. Institutional agents are also instrumental in providing access to educational resources, and emotional support (Bensimon & Dowd, 2012; Chase, Bensimon, Shieh, Jones, & Dowd, 2013).

Campus racial climate. Within the campus environment, there are several layers that I will investigate to inform my study. These layers consist of the campus racial climate,

responses to a negative campus racial environment, the STEM academic environment including pedagogical practices and intervention initiatives. This investigation is necessary because these subsets of the collegiate environment are significant factors in the success or failure of underrepresented college students. First, the campus climate can be describe as the manner in which a student perceives his or her college environment (Lewin, Lippet, & White, 1939, Reid & Radhakrishnan, 2003) and for racially underrepresented students, for example African American women, this campus climate will manifest into a campus racial climate, which could be positive or negative and is influential in their undergraduate socialization because racial and ethnic experiences tend to differentiate educational outcomes for African American women in STEM disciplines. The institution's racial climate can be described as "the result of a judgment process aggregating the evaluations an individual makes about his or her environment at different levels of observation" (Reid & Radhakrishnan, 2003, p. 264). Research has documented that African American (Davis, 1994; Fisher & Hartmann, 1995) and Latino (Hurtado & Carter, 1997) students, as compared to other student populations, have purported the most negative perceptions of the campus climate.

Throughout college, African American students can experience a campus racial climate with obstacles that negatively impact their adjustment at PWIs, as compared to their White counterparts (Anderson, 1988; Henderson, 1988; Russell & Atwater, 2005). Some of these obstacles reveal themselves as feelings of separation from the college

community as well as racial discrimination (Anderson, 1988; Henderson, 1988; Neville, Heppner, Ji, & Thye, 2004). Barriers such as stereotype threat (Steele, 1997; McGee & Martin, 2011), microaggressions (Solórzano et al., 2000), intersectionality (Collins, 1990), the lack of a sense of belonging (Seymour & Hewitt, 1997; Johnson, 2012), and the lack of self-efficacy (Bandura, 1986) could continue to hinder the persistence and degree attainment of African American women in engineering and thus warrant further examination.

With this notion, a campus racial climate can be considered to be negative and described as a "climate of prejudice and discrimination in the classroom and on campus" and has been recognized in studies by researchers such as Hurtado (1992, 1994); Hurtado, Carter & Spuler (1996) and Smedley, Myers & Harrel (1993) as the most significant factor contributing to the disparity in persistence between students of color and White students (Cabrera et al., 1999, p. 135). Brown, Morning, and Watkins (2005) determined that perception of racism and discrimination for African American students has a direct and negative effect on GPAs and graduation rates, concluding that a positive campus climate could improve persistence and degree attainment of African American students. These findings are substantiated by additional researchers who suggest that an unwelcoming campus climate caused by prejudicial and/or discriminatory behavior can be detrimental to underrepresented students of color, causing them to withdraw from their selected major (Fleming, 1984; Hurtado, 1992; Smedley, Myers, & Harrel, 1993). This

effect is particularly evident for African American students attending PWI's, where prejudicial and discriminatory behavior manifests itself into a negative racial campus climate (Reid & Radhakrishnan, 2003).

Rankin and Reason (2005) evaluated the college racial climate for underrepresented populations where they defined harassment as "any offensive, hostile, or intimidating conduct that interferes unreasonably with one's ability to work or learn on campus" (p. 43). The researchers determined that 25% of students experienced harassment and that 33% of students harassed were students of color. The researchers also concluded that students of color are more likely to observe negative conduct as well as "view the campus climate as racist, hostile, and disrespectful" (p. 52). These environments allow for this type of behavior to continue and tend to lack institutional policies and procedures that focus on diversity. In contrast, a positive campus racial climate includes: (a) the purposeful presence of faculty, administrators, and students of color; (b) a curriculum that reflects the experiences of people of color; (c) programs that support recruitment, retention, and graduation of students of color; and (d) a mission and associated mission statement that reflects the institution's commitment to diversity and heterogeneity (Guinier, Fine, & Balin, 1997; Hurtado, 1992, 1994; Solórzano, Ceja, & Yosso, 2000).

Microaggressions. Microaggressions can manifest within a campus racial climate. According to Solórzano, Ceja, and Yosso (2000), "microaggressions are subtle insults (verbal, nonverbal, and/or visual) directed toward people of color, often automatically or unconsciously" (p. 60). Another vantage point upon which to examine microaggressions is through the clash of racial realities (Sue, Capodilupo, Torino, & Bucceri, 2007). Research demonstrates that the interpretation of racial realities diverge when you compare the interpretation of people of color to the interpretation of White people (Harris Poll commissioned by the National Conference of Christians and Jews, 1992; Jones, 1997; Sue et al., 2007). The research purports that White individuals in America are inclined to believe that people of color are progressing well in life, that discrimination and racism are no longer relevant and that they as a population are not racist (Sue et al., 2007). On the contrary, people of color recognize White people as "(a) racially insensitive, (b) unwilling to share their position and wealth, (c) believing they are superior, (d) needing to control everything, and (e) treating them poorly because of their race" (Sue et al., 2007, p. 277). These interpretations exacerbate the existence of microaggressions due to the lack of common ground (Sue et al., 2007), and people of color experience these types of interactions with White people on a daily basis (Solórzano et al., 2000). Women in STEM majors often encounter microaggressions specific to race, ethnicity and gender in classrooms comprised primarily of White men (Sosnowski, 2002). Inside the STEM classroom, African American students can

experience microaggressions by feeling invisible and ignored, suggesting to them that their voice does not count in this environment. Moreover, when these students are reviewing the curricula they realize that their race and/or gender is either distorted, omitted or stereotyped, which leaves them feeling marginalized (Solórzano, Ceja and Yosso, 2000).

Faculty members and other students can engage in microaggressions that are often presented innocently and are perpetuated against African American students; however, these offenses progress until they become burdensome to African American student (Pierce et al., 1978). According to Solórzano et al. (2000), faculty members who have low expectations of African American students' abilities contribute to these microaggressions, promoting negative interactions that result in a student's sense of invisibility and sense of academic self-doubt.

Outside of the classroom, Solórzano et al. (2000) found that African American students encounter microaggressions and stereotypes, causing them to feel tension and discomfort in places like the library and other public spaces. These microaggressions affect African American students in a myriad of situations, and continual microaggressions cause self-doubt and feelings of separation. For some students, the environment filled with microaggressions created by White faculty and students took a toll on their academic performance, compelling them to leave the institution (Solórzano, 2000). Other students remained and created counterspaces that served as safe

environments where microaggressions could be challenged and where students could support one another in their academic and social growth (Solórzano et al., 2000).

Stereotype threat. Steele and Aronson (1995) stated that:

> the existence of such a stereotype means that anything one does or any of one's features that conform to it make the stereotype more plausible as a self-characterization in the eyes of others, and perhaps even in one's own eyes, (p. 797).

This threat can exert pressure on students and their academic progress, in turn causing inferior test score results and, if chronic, can cause “disidentification” (Steele, 1997 p. 614), which serves to have women become indifferent to competitive environments dominated by men, thus protecting them from the environment. The disidentification can cause women to become demotivated, ultimately hindering their academic performance (Steele, 1997). This threat causes women to question their abilities in math and science, particularly advanced math and science. This lack of confidence in their ability is a response to the systemic messaging that questions their ability (Spencer, Steele & Quinn, 1999). These feelings also occur for African American students, however; these threats are more difficult to avoid because the threat encompasses a wider academic area and for African American women, the threat is more complex due the double-bind of gender and race (Malcom, Hall & Brown, 1976)

In order to combat stereotype threat, African American students use “stereotype management,” in response where this management process is defined as “academic resilience (traditionally valued high achievement in spite of negative intellectual and societal-based stereotypes and other forms of racial bias) among Black mathematics and engineering students” (McGee & Martin, 2011, p. 1354). According to McGee and Martin’s (2011), mathematics and engineering students worked hard academically and performed exceptionally well, seeking to prove to the faculty and their student counterparts that they were competent and that the stereotype was incorrect. Though this response resulted in academic success, the students understood that the stereotype threat still existed and that they were always battling this imposed inferiority (McGee and Martin, 2011).

Engineering Department Racial Climate. The campus environment is an integral element of and plays a crucial role in providing the necessary support for students to persist to graduation; however, the environment can produce barriers that obstruct goal-oriented behavior (Murray, 1938; Weiner, 1972). As demonstrated by the examination of undergraduate student socialization and campus climate by which underrepresented students are exposed, it has been concluded that these environments can lend themselves to student academic success or failure. For example, the engineering departmental

climate can contribute to academic success or failure for African American women in engineering.

This success or failure can be attributed to the amount of support received, faculty-to-student interactions as well as student-to-student interactions experienced within the department and program (Chachra et al., 2009; Kuh, 1995; Pascarella & Terenzini, 2005). Due to these environments, students had to deal with the significance of race in their educational surroundings, some for the first time (Tate & Linn, 2005). Research conducted by Howard and Hammonds (1985) concluded that African American students are attracted to majors and environments where these minefields do not exist and where they are not labeled as inferior. This labeling is indicative of science majors at PWIs (Howard & Hammonds, 1985) and is an ingredient of the "hidden curriculum" which implies that stereotypical social rules are applied in the academic environment (Apple, 1986) This hidden curriculum is a microcosm of the larger societal message stating:

> Since the hidden curriculum is taught (implicitly) through the kinds of participatory mechanisms that work so powerfully in out-of-school contexts, it is not surprising that sometimes the messages about social class and social roles in the hidden curriculum are understood by students more deeply than the messages about scientific concepts in the explicit curriculum. (Brand, Glasson, and Green, 2006, pp. 3-4)

Specific to nontraditional majors such as STEM, Morris and Daniel (2008) concluded that women and underrepresented minorities experience a chilly climate that produces potential disadvantages when they participate in a White male-dominated academic environment (Chism, 1999). Tate and Linn (2005) established similar findings while studying five upper-class women of color in engineering at a large public university to determine how an individual's identity influenced her experiences. These students experienced "social discomfort within their academic environment in a variety of ways, such as extracurricular activities, perceived academic ability, stereotypes, race or ethnicity, and gender" (p. 488). Some students felt unwelcome and experienced discomfort socially because the college community and environment were much different from their home experiences where they had encountered fewer White people. These feelings of social discomfort can be exacerbated by the intersectionality of these women having the double bind of being women and African American.

The STEM academic environment and pedagogical practices. Weidman (1979) studied undergraduate socialization as it was experienced in academic departments and found that this environment is a significant normative focal point due to the influences of faculty members, interaction with student counterparts and time spent in the academic department environment (Feldman & Newcomb, 1969; Lehmann & Dressel, 1962). As time in this environment continues, students tend to respond to the influences of faculty

members more than peers and family, because faculty members are seen to be more relevant particularly when career aspirations are the focus (Weidman, 1989). Numerous STEM educational environments consist of predominately White men and this non-diverse environment often contributes to a negative campus racial climate for underrepresented students (Hurtado, Milem, Clayton-Pedersen & Allen, 1999). This classroom environment and associated pedagogical practices are influential factors on the persistence of African American women in engineering, exist within STEM academic departments and deserve further investigation.

The pedagogical practice used in education can help or hinder the persistence of a student. Barr and Tagg (1995) and Bok (2006) purport that lack of persistence may be perpetuated by pedagogical practices that are not conducive to a learning-centered environment which "frames learning holistically, recognizing that the chief agent in the process is the learner" (p. 10) and where the learning is controlled by the learner and not by a teacher (Barr & Tagg, 1995). Specific to STEM education, Bernold, Spurlin, and Anson (2007) suggest that reform is needed to improve the learning experience in engineering majors. The traditional engineering learning environment is lecture based where information is delivered by faculty members, who lecture in the classroom (Rugarcia, Felder, Woods & Stice (2000); Elshorbagy & Schonwetter (2002). In this atmosphere there is little dialogic conversation and information flow travels in one direction from faculty to student. The North Carolina State University students who

participated in a study, for example, appeared to struggle with learning in a non-learning environment like lecture halls where students are compelled to memorize information presented. These students preferred an atmosphere that was conducive to "divergent thinking, innovation and subjective interpretations" of the subject matter (p. 271). Johnson (2007) furthered the research by studying African American, Latina, Native American and Asian American women in physics to determine how they interpreted their science environment. The study identifies the large competitive lecture hall environment as a factor that hindered these women of color. Large classroom environments produced feelings of isolation for women of color because the large lecture hall environment did not allow women in the class to be recognized by faculty members. This non-recognition perpetuated feelings of isolation, which continued to encumber women of color's persistence in STEM majors (Johnson, 2007). Brainard (2007) performed research on these types of non-learning environments demonstrating that only a fraction of the information was retained and students did not to fully understand information, causing persistence and degree attainment to be hindered. Moreover, traditional higher education has been taught in a "banking model" process whereby faculty lecture and students absorb information with minimal-to-no discussion, which is not conducive to student learning (Barr & Tagg, 1995; Bok, 2006; Freire, 1994).

Research also suggests that some students, particularly students of color, learn more effectively in an active and experiential learning environment (Kuh, 1995). R.

Felder, et al. (1998) argued that pedagogies that include "cooperative learning, open-ended questioning, multidisciplinary problem formulation and solution exercises, and criterion-referenced grading" offer students a better overall learning experience (p. 470), when compared with traditional lecture-based engineering teaching styles. The population of students who participated in the experiential and nontraditional learning environment persisted more successfully in the program, as compared to students who participated in the more traditional teaching and lecture model. The students in experiential learning environments developed a higher level of critical thinking skills, were able to work more independently, and interact with peers more successfully (R. Felder, et al., 1998). Experiential learning has a significant impact on academic and social experiences of underrepresented populations in engineering, like African American women. This type of learning is necessary for students to determine the relevance of the STEM course work being studied. Experiencing the relevance and social value of the STEM learning creates a more impactful learning encounter (Bonous-Hammarth, 2000; Hurtado, Newman, Tran, Chang, 2010). Thus, understanding the manner in which STEM knowledge will be use in the students' life experiences is important.

In the STEM academic classroom environment, particularly in the first year, students face another obstacle, known as the "weed-out" process. "Weed-out strategies are perceived as a test for both ability and character and are the main mechanism by which science, math, and engineering disciplines seek to find those students presumed to

be the most able and interested" (Seymour & Hewitt, 1997, p. 122). Many of the first-year STEM courses are developed to build a foundation for the students who intend to concentrate in the STEM field and possibly work towards an advanced degree. These courses cover a breadth of information that is consistent with advanced study, but is not necessary for an introductory course (Bok, 2006).

The weed-out process begins during the first semester of freshman year in courses that are not interesting or engaging and usually have no correlation with the subject that influenced the students' pursuance of a STEM major (Duderstadt, 1990; Gainen, 1995; Maton, Hrabowski, & Schmitt, 2000; Treisman, 1992). These types of courses can work like a sieve and begin to sort or weed out students who are less certain of their aspirations because this type of classroom environment could convey the message that students do not fit or are not welcome (Baldwin, 2009). This causes students who could contribute to and benefit from the STEM educational experience to transfer out into non STEM majors (National Research Council, 2003; National Science Foundation, 1996).

This weed-out process discourages underrepresented populations, like African American students, from persisting in science majors because it perpetuates a competitive environment, exacerbates the pace and workload of the course and negatively affects grading and assessment processes (Seymour & Hewitt, 1997). The weed-out process is a hierarchical and competitive method allowing for the best performing students, as identified by the professor based on test scores and interaction with the professor, while

students who are weeded out appear to be academically deficient (Massey, 1992; Seymour & Hewitt, 1997). Those students who succumb to the weed-out process switch out of STEM majors or drop out of college (Brand et al., 2006). These weed-out courses are created either through tradition or by design (Austin, 2011), and this weed-out process is a significant example of symbolic violence as defined by Bourdieu (2004) because this process of weeding students out is so embedded that it no longer warrants justification by faculty members. Furthermore, White men, who dominate the engineering field, apply "categories constructed from the point of view of the dominant to the relations of domination, thus making them appear natural" (p. 339). In this case, an engineering environment dominated by White men is often constructed with a process that is used to determine the students who are and are not worthy of continuing on in engineering and, in this instance, White men are worthy of continuing, whereas other students like African American women are not.

Sense of belonging and self-efficacy. The climate of college and departmental racial environments are factors that can affect one's sense of belonging and self-efficacy, whether positively or negatively, and according to research literature, sense of belonging in the STEM community is an important contribution to women and their persistence (Han, Sax, & Kim, 2007; Margolis, Fisher, & Miller, 2000; Seymour & Hewitt, 1997); however, the embedded notion that STEM careers exist in environments dominated by

White men can negatively influence the sense of belonging for women in STEM majors, branding the STEM career choice less attractive for women (Kim, Fann, & Misa-Escalante, 2009). The sense of belonging is limited further for women in STEM majors because they are often surrounded by men, both students and faculty, who often make them feel unwelcome by treating them differently, ignoring them and/or degrading them (Seymour & Hewitt, 1997). This type of environment whereby men emphasize the belief that women do not belong continues to negatively influence -the women and their confidence (Margolis et al., 2000).

Johnson (2012) added to the literature as she examined the role of a campus racial climate as it pertains to a sense of belonging among racially diverse women in STEM majors, revealing a negative relationship between women of color and their sense of belonging on college campuses. The negative relationship stems from the unique challenges experienced due to the decontexualization of science and the meritocratic structure, as well as "forms of racial oppression, discrimination and prejudice, and these experiences are distinct from the racial privilege experienced by White women in predominately White environments as STEM" (p. 345). These challenges create an uneven playing field that can hinder women of color and their persistence (Johnson, 2012). In conjunction with sense of belonging, self-efficacy can also be affected when African American women are faced with a negative campus racial climate. According to

Bandura (1986), self-efficacy is referred to as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). Bandura (1997) also suggested that self-efficacy decides:

> the courses of action people choose to pursue, how much effort they put forth in given endeavors, how long they will persevere in the face of obstacles and failures, their resilience to adversity, whether their thought patterns are self-hindering or self-aiding, how much stress and depression they experience in coping with taxing environmental demands, and the level of accomplishments they realize (p. 3).

One foundation of self-efficacy is the influence that other individuals have on another, whether purposeful or not. This self-efficacy source manifests differently in women than in men due to the negative messages women receive from other students and faculty (Marra, Rodgers, Shen & Bogue, 2009), and these messages further lessen feelings of inclusion for African American students as compared to other student populations (Marra et al., 2009).

These experiences are focused on issues of individuals and are created by focusing on women's characteristics such as their life experiences, behaviors, attitudes, skill-sets, and aptitude, thus affecting their persistence (Astin & Sax, 1996; Cronin & Roger, 1999; Fox 1998; Ong, 2005); however, the more significant factors could be viewed as "institutional issues" (Fox, Sonnert, & Nikiforova, 2009, p. 334). In examining

the individual issues, women are perceived, by faculty and college administrators to possess a mindset, a skill-set, and experiences that could affect their persistence and success (Fox, 1998; Ong, 2005). For instance, lower levels of self-confidence in math-related subjects, as well as lack of motivation to excel in scientific areas, may become more of an obstacle for women in the pursuit of a STEM career as compared to men (Astin & Sax, 1996). The focus on institutional issues, however, is a more viable lens compared to the individual issues lens to use when the experiences of African American women in engineering are discussed (Fox, Sonnert, & Nikiforova, 2009). Persistence and degree attainment of women of color are affected more significantly from institutional settings in which they are educated as compared to individual issues they experience (Fox et al., 2009). For example, an exclusive environment, a lack of resources and/or a double standard for academic evaluations could deter women of color and their success (Fox, 1998, 2001; Seymour & Hewitt, 1997). Within institutional issues, women of color face the "double devaluation" (p. 11) because of their ethnicity or race and gender. Faculty members expect this population to underperform and perceive them to be less competent than White men (Hall & Sandler, 1984). Moreover, faculty may be less willing to support women of color when they work on research projects or teaching assistant assignments and these messages are components of the "hidden curriculum" (Apple, 1986).

This distinction between individual issues and institutional issues is relevant because there has been and continues to be a long-standing debate within research

literature as to where responsibility rests, as it relates to underrepresentation of women in science and engineering majors (Fox, 1996; Sturm, 2006). In reevaluating college and/or departmental climates, Checkoway (2001) suggested: "for democracy to function successfully in the future, students must be prepared to understand their own identities, communicate with people who are different than themselves, and build bridges across cultural differences in transition to a more diverse society" (p. 267). In order for this new democratic society to occur, unwelcoming campus and departmental climates described by Hurtado (1992); Smedley, Myers, and Harrel (1993); and Tate and Linn (2005) must transform into environments of inclusiveness and welcome. Perna et al. (2009) depicted this type of environment while examining Spelman College, a single-gender Historically Black College and University (HBCU), and the institutional involvement that supports students. This research concludes that HBCUs have the propensity to provide a more supportive, compassionate and cultivating environment for students allowing for academic achievement and success, as compared to PWIs due to institutional policies and programmatic systems that are implemented and integrated throughout the institution (Perna et al., 2009).

Intervention activities – responses to negative racial campus climate. As research has confirmed, there is an underrepresentation of African American women in engineering due in part to a negative academic environment. In contrast to literature that examines

this underrepresentation and negative experiences facing African American women in engineering, there is additional literature that focuses on intervention activities that are responses to negative racial campus climate and these findings are significant because they contribute to persistence of engineering students, particularly underrepresented students of color and women as they persist to degree completion. The literature examines methods by which higher education institutions can positively affect persistence and degree completion of underrepresented students, like African American women in engineering. These methods consist of faculty engagement that encourages confidence and persistence (Seymour & Hewitt, 1997; Rendon, 1985). Komarraju, Musulkin and Bhattacharya (2010) concurred and stated that faculty interactions can be significant in the student's motivation and achievement. Other methods that positively affect African American women in engineering are aggressive advising whereby advisors assist underrepresented students in STEM (Matyas, 1991; Velez, 2000; Maton, Hrabowski & Ozdemir, 2007); mentoring efforts that help to decrease attrition, increase grades and increase self-efficacy (Santos et al., 2002; Schwitzer & Thomas, 1998; Tsui, 2007); experiential models of learning (Kuh, 2005); learning center environments (Barr & Tagg, 1995 & Bok, 2006) and learning environments that can increase gender equity while providing positive experiences for the women in STEM programs (Green & Glasson, 2009; Tate & Linn, 2005).

In contrast to the weed-out process and other deterrents to learning, Perna et al. (2009) concur with Buncick, Betts, & Horgan (2001) and Colbeck et al. (2001), concluding that there are benefits to incorporating student achievement and academic confidence in STEM curricula and pedagogical practices. Buncick et al. (2001) suggest that students are more confident in their academic ability when they are inspired to make connections to their real-life understanding and prior learning and when they are actively involved in the learning process. Women are also more confident in their decision to enroll in STEM majors when academic work is related to their experiences (Margolis, Fisher, & Miller, 2000). Perna et al. (2009) conclude that there are, in fact, "benefits of culturally-relevant pedagogy and these classroom activities appeared to be particularly effective for promoting classroom participation among women and Blacks" (p. 17). Furthermore, R. Felder, Felder and Dietz, (1998) state that pedagogies that include "cooperative learning, open-ended questioning, multidisciplinary problem formulation, solution exercises, and criterion-referenced grading" would offer students a better overall learning experience (p. 470). Teaching styles that are more inductive are more affective whereby allowing students to actively participate in the learning (Barr & Tagg, 1995; Bok, 2006, Prince & Felder, 2006).

Research indicates that some students, particularly students in underrepresented groups, learn more effectively in an active and experiential learning environment such as a lab experience versus a lecture based atmosphere where no dialogic conversation or

actions occur (Kuh, 1995). Studies also demonstrate that classroom climates may be significant in determining reasons why underrepresented populations, like African American women, tend not to persist as compared to their White men (Kimball, Cole, Hobson, Watson & Stanley, 2008; Newbill & Cennamo, 2008). Further, Glazer-Raymo (2008) and Seymour & Hewitt (1997) posits that traditional, non-dialogic lecture-based STEM classrooms favor White men and that teaching styles associated with this environment tend to alienate underrepresented populations (Seymour & Hewitt, 1997; Sonnert, 1995). Kuh (2008) suggested that an ingredient needed for a more successful learning environment would include high-impact practices because these learning opportunities have a positive effect on students who have been traditionally underrepresented in a particular field of study. These high-impact practices can take on the form of activities such as first-year seminars, learning communities, collaborative assignments and service-learning initiatives, enabling students to grasp the curriculum content through hands-on learning and action (Kuh, 2008). For example, practices such as collaborative team projects allow students to learn by doing, as well as learn from their fellow students, and service learning opportunities allow students to use skills learned to solve real world challenges (Kuh, 2008). These pedagogical methods are effective because they require students to engage purposefully and commit to activities as well as require students to collaborate with faculty and other students over a long period of time. These types of activities increase the prospect that students will experience diversity by

collaborating with other students from different backgrounds. Assuming that negative interactions, like microaggressions or stereotype threats are not apparent, activities such as interaction with peers and faculty as well as involvement in other campus activities in and out of the classroom can positively contribute to the overall campus experience (Kuh, 1995), especially for women in engineering (Chachra et al., 2009).

These activities are beneficial due to the positive faculty-to-student interactions because these types of activities contribute to retention and persistence in college education (Pascarella & Terenzini, 2005), and these factors are particularly effective for students of color (Hernandez, 2000; Jackson, Hall, & Smith, 2003). Moreover, faculty reassurance and support have a positive impact on student persistence and graduation in STEM fields of study (Maton & Hrabowski, 2004; Packard, 2004; Perna et al., 2009). Active student-to-faculty interaction is also an important element to the persistence of African American women in STEM curricula (Rendon, 1985), and this positive faculty interaction increases the likelihood of STEM undergraduate students' plans to attend STEM graduate studies (Eagan, Hurtado & Chang, 2010).

The Intersectionality of Race and Gender - The Double Bind. Intersectionality theory pertains to the manner in which an individual's gender and race function together and are not mutually exclusive. Consequently, as gender and race interact, individuals construct various structures of prejudice and disparities (Collins, 1990). During their pursuance of

engineering degree attainment, women of color experience a response from others, relative to both their race and gender, resulting in the significance of the intersectionality of race and gender. Lord et al. (2009) conclude that "failing to consider race in any analysis of gender ignores the intersectionality of both these sociocultural constructs" (p. 185). This situation is a dimension of the double bind phenomenon, whereby "it does not matter whether one is being hit with the club of sexism or racism--they both hurt" (Malcom, et al., 1976, p. 4).

Malcom et al., (1976) advances the notion that the double bind experience is apparent in STEM programs because women of color have been traditionally disregarded in STEM programs due to the prejudice they receive regarding their gender and race or ethnicity. Moreover, programs intended for women of color are designed for women in general, and these initiatives, produced to support underrepresented students, sometimes focus on men, are too general and neglect the specific needs of underrepresented women (Malcom et al., 1976). This becomes evident when the content delivered in programs emphasizes experiences and nuances of women in general, and this occurs because the majority of participants who deliver these programs are White (Malcom et al., 1976). This type of program delivery remains evident in engineering, math and computer science disciplines due to the "rigid cultures, structures, and lack of faculty diversity in these fields" (Malcom, L. & Malcom, S., 2011, p. 166). Concurring with this concept, Johnson (2007) concluded that negative socialization occurs in scientific curriculum and

in STEM classrooms when individual characteristics like race and gender are deemed irrelevant to the teaching and learning, causing women of color to feel insignificant.

Science Identity

Within this academic environment, African American women in engineering develop varying science identities. In this identity model, a student with a positive science identity is one who:

> Is competent; she demonstrates meaningful knowledge and understanding of science content and is motivated to understand the world through science. She also has the requisite skills to perform for others her competence with scientific practices (e.g., uses of scientific tools, fluency with all forms of scientific talk and behavior, and interacting in various formal and informal scientific settings). Further, she recognizes herself, and gets recognized by others, as a "science person". (Carlone & Johnson, 2007, p. 1190).

This science identity model depicts three interconnected elements: competence, performance and recognition, acknowledging the fact that science identity is socially constructed and that the three elements are related. The science identity model is grounded in the assumption that and individual's ethnic, racial and gender identities affect her science identity. This identity model is relevant to this study because African American women are underrepresented in STEM education and carry the double bind

challenges of race and gender (Malcom & Malcom, 2011). Moreover, this identity lens aids in the examination and pursuit of a more equitable science education for all students by investigating how students make meaning of their experiences in STEM majors. Students are socialized prior to their entrance in college, from their background, precollege pressures, and parental socialization. These students then experience undergraduate socialization through non-college reference groups, their college experience and their in-college pressures, all to produce socialization outcomes.

Women who have embraced their science identity can also possess an altruistic science identity. These women "created their own definition of science, redefined whose recognition mattered to them, and, in some cases, redefined what it meant to be a woman of color in science. In short, they engaged in successful cultural productions". (Carlone & Johnson, 2007, p. 13). This trajectory is created when the reason for studying science is less about the science and more about the altruistic initiatives that can be developed and implemented with the use of the science.

Women can also have a disrupted scientist identity experience that interrupts their science identity pursuit. With this identity women describe and focus on situations and experiences "where they felt overlooked, neglected, or discriminated against by meaningful others within science" (p. 1202). They could also feel as though other individuals within the science organization do not recognize them as a science person and do recognize them as a member of the "stigmatized groups", (p. 1202). Moreover,

women of color can perceive that their behaviors and/or their appearance can prompt gender, racial or ethnic acknowledgement that subjugated their opportunity of being recognized as good science students.

Aspirations, Career Choices, Life Values and Style Preferences

Weidman (1989) suggested that outcomes associated with undergraduate socialization can manifest into aspirations, career choices, life values and style preferences. Aspirational trends in career orientation have been changing and women have made more changes than men. Women are now aspiring to combine their person goals with their career ambitions whereby establishing a career is as important as having a family (Hackett, Lent & Greenhause, 1991). These career choices can be attributed to person-environment fit theories (Hackett, Lent & Greenhause, 1991), suggesting the degree of similarity between an individual's personality and the demands of the working environment determine occupational success, satisfaction and longevity (Hackett & Lent, 1992). Engineering work environments can be chilly atmospheres for African American women (Chubin, May, & Babco, 2005), and this experience could decrease similarities between an individual's personality and demands of working environments, thus reducing occupational success, satisfaction and longevity (Hackett, Lent & Greenhause, 1991). Values change as student experience undergraduate socialization. Students enter college with their parents' values obtained through parental socialization and these values

are enhanced or altered during undergraduate socialization (Weidman, 1989). Life style preferences can be defined as 'the manner in which people conduct their lives, including activities, interests, and opinions' (Peter & Olson, 1994, p. 463). Undergraduate socialization is instrumental in life style preferences because the socialization process develops these preferences as individuals participate in the college experience (Weidman, 1989).

Achievement Goal Theory

Weiner (1972) posits that achievement theory is a cognitive theory that "assumes that one's beliefs about the likelihood of attaining a goal (success at an achievement task) mediate between the perception of the task stimulus and the final achievement-related response", (p. 169). Achievement goal theory is a significant ingredient to this study because it describes the motivational methods students, in this case African American women in engineering, use to cope and persist to degree completion. Underrepresented students like African American women in engineering persist to degree completion when they utilize one of two or both motivational constructs of achievement goal theory: performance goal or mastery goal strategy to overcome some racist and sexist barriers that confront them. They may select a performance goal strategy because they are motivated by and inclined to exceed academic standards and outperform their peers in order to defy stereotypes; aiming for and attaining this goal enables students to increase

their self-worth (Covington, 1984; Dweck, 1986; Nicholls, 1984) and potentially secure their science identity (Carlone, 2007). If students are in a conducive environment that is learning centered collaborative and non-competitive (Barr et al., 1995; Bok, 2006; Kuh, 2005) then students may be more inclined to employ mastery goal strategies which provide them with a focus on mastering the subject matter and developing new skills, thus improving on the level of competence (Brophy, 1983; Meece, Blumenfeld & Hoyle. 1988; Nicholls, 1989). However, underrepresented populations, such as African American women engineering students, may not persist in majors where they experience negative messaging including stereo-type threat (Steele, 1997), microaggressions (Solórzano, Ceja & Yosso, 2000), and a chilly climate (Morris & Daniel, 2008). In these instances, the unwelcoming environment could lead students to implement an avoidance strategy which could deter them from persisting and ultimately from degree completion.

Achievement goal theory integrates cognitive and affective elements of behaviors that are goal driven (Ames & Archer, 1988: Dweck, 1986; Dweck & Elliott, 1988; Dweck & Leggett, 1988) bringing forth behaviors by incorporating a collection of beliefs, acknowledgments and results that construct the objective of these behaviors (Weiner, 1986). These varying behaviors constitute different methods of advancing, participating in and reacting to activities related to achievement (Ames, 1992b; Dweck et al., 1988). According to Dweck et al., (1988), achievement goals are defined as involving a "program" of cognitive process that has "cognitive, affective and behavioral

consequences" (p. 11). Within achievement goal theory, there are two prominent constructs that are utilized in the literature. These constructs differ due to their relationship to motivation and numerous researchers have labeled these constructs differently. Dweck (1986;) and Dweck et al., (1988) label the constructs as learning focus and performance focus; while Maehr and Nicholls (1980) labeled them as task-involvement and ego-involvement goals and finally, Ames and Archer (1988) labeled the terms as mastery and performance goals. For the purposes of this study, the label and associated definition used for these constructs will be mastery and performance goals. I selected mastery because it suggests that an individual has become proficient at a specific subject matter. The performance term was selected because it resonated with me and my experiences as an engineering student because I was always trying to perform or outperform my fellow students. These concepts will be used in the study's interviewing process to explore the women's academic achievement goal motivation styles.

Mastery goals and performance goals are derived from "different environmental or instructional demands, a result in qualitatively different motivational patterns" (Ames, 1992, p. 262). Fundamental to mastery goals is the understanding that the effort and result of these efforts are modified depending on circumstances and interpretations of these circumstance. Due to this understanding in the use of mastery goals, achievement directed behavior is sustained over time (Weiner, 1979, 1986). When an individual uses mastery goals, his or her focus is on the inherent significance of learning (Butler, 1987;

Meece & Holt, 1990; Nicholls, 1984). Brophy (1983) has defined "motivation to learn as an enduring disposition to value learning for its own sake – to enjoy the process and take pride in the outcomes of experiences involving knowledge acquisition or skill development" (p. 1). With this focus individuals seek to develop new skill sets, increase levels of competence and overall, achieve self-defined mastery of the content (Ames, 1992; Brophy, 1983; Meece, Blumenfeld, & Hoyle, 1988; Nicholls, 1989).

In contrast, the tenant of performance goals is focused on an individual's capability as well as their sense of self-worth (Covington, 1984; Dweck, 1986; Nicholls, 1984b) coupled with the act of exceeding academic standards and performing better than others with little exertion (Ames, 1984; Covington, 1984). Due to this cognitive belief, the learning process is a means to an end, and is a method by which to obtain the desired outcome (Nicholls, 1979, 1989). With this notion, attention is concentrated on achieving an outwardly defined success (Ames 1992). Furthermore, the individual's behavior is guided by his or her ability and the individual's self-worth is determined by an observation of his or her own ability to achieve success as compared to others (Covington & Beery, 1976; Covington & Omelich, 1984). Also according to Covington et al. (1984), the use of effort can impede the self-concept of ability when working hard does not lead to success and these consequences could stifle these efforts in the future (Covington & Omelich, 1979).

An additional component of achievement goal theory is work avoidance. The work avoidance goal strategy motivates the student to exert minimal effort (Brophy, 1983; Duda & Nicholls, 1992), which in turn has a negative effect on motivation and performance (Archer, 1994; Meece et al, 1988; Nicholls, Nolen & Patashnick, 1985; Nolen, 1988). The student who uses this strategy has a low self-perception of his or her own competence and avoids demonstrating this lack of competence relative to their peers (Elliot, 1999). This strategy is also used when a student works hard, but does not reap the benefit of the hard work. As an example, African American women in engineering could use this avoidance goal strategy when their efforts are not demonstrating their academic understanding so they avoid situations rather than work through them.

Summary of the Literature

The research areas discussed in this literature review are not mutually exclusive, as they examine the negative and positive experiences of African American women in engineering, thus informing my study. As the literature suggests, socialization of African American college students is influenced by their background, the campus climate and academic environment as well as their interaction with faculty and student peers. These factors influence African American women's persistence, identity and sense of belonging, for example, and can be examined through the lens of the academic and social college normative context (Weidman, 1989). The research further suggests that these

factors are potentially more negative when African American women participate in majors dominated by White men, where there are fewer opportunities for support. Moreover, the campus climate can lend itself to the perpetuation of a negative environment for African American women in STEM by further discouraging them from persisting and attaining degree completion. These experiences are intensified for African American women because they encounter challenges related to intersectionality of race and gender, along with all of the stereotypes and misconceptions associated. In contrast to the literature that examines the negative experiences facing African American women in engineering, research also focuses on positive experiences. Espinosa (2011) as well as Hill, Corbett and St. Rose (2010) focused on intervention activities and the significance these activities have on assisting engineering students, particularly underrepresented students of color and women as they persist to degree completion. Literature demonstrates there to be methods by which higher education institutions can positively affect persistence and degree completion of African American women in engineering. These methods consist of activities such as: faculty engagement (Rendon, 1985; Seymour & Hewitt, 1997); strong science identity development (Carlone & Johnson, 2007; Pascarella & Terenzini, 2005); the integration of student achievement and academic confidence in STEM curricula and pedagogical practices; mentoring efforts (Santos et al., 2002; Schwitzer & Thomas, 1998; Tsui, 2007); experiential models of learning (Kuh, 2005); and learning centered environments that can increase gender and racial equity

while providing positive experiences for underrepresented STEM students (Barr & Tagg, 1995; Bok, 2006; Williams, Layman, Berenson & Seaman, 2007). The above research demonstrates the notion that higher education institutions have an important role to play in the success of African American women as they attempt to persist to degree attainment within STEM majors, specifically engineering. With this understanding of the literature, the undergraduate socialization model (Weidman, 1989) along with CRT (Delgado &Stefancic, 2001) were used to guide the study as I examined experience of African American women in engineering as they persist in their academic environment. The undergraduate socialization model is an important framework for the examination of African American women in engineering. However, CRT is needed to provide a focused lens on the experiences of African American women in engineering because topics of race and racism are necessary for a complete conversation.

Conceptual Framework Guiding this Study

Conceptual frameworks are derived from epistemological foundations that exist throughout higher education. Stanley and Wise (1988) propose that "an 'epistemology' is a framework or theory for specifying the constitution and generation of knowledge about the social world; that is, it concerns how to understand the nature of 'reality'" (p. 188). Specific epistemological structures not only focus on knowledge and processes by which to recognize this knowledge, but they also focus on who the knowers are and how these

individuals are selected to be in the know, as well as the knowledge itself and the means by which various knowledge is deemed necessary while other knowledge is discarded (Stanley & Wise, 1988).

According to Rendon (2009), epistemology "refers to a theory of knowing" and can be further described as the ways of knowing (p. 66). In concert with epistemology is ontology, referring to "the nature of being" (p. 67), which should work to complement an epistemological belief (Rendon, 2009), allowing for an individual to understand the object in question through his or her own reality. When the individual and object are connected and not separated, a participatory epistemology emerges as "the knowing that occurs when the perceiver and the perceived are united as a single consciousness" (Lachman, 1998, p. 8). More specifically, the learner is connected with information being learned and varied methods of reflective practices providing access to "deep awareness, focus, compassion, social change, transformation, creativity and inspiration as well as intellectual understanding" (Rendon, 2009, p. 134).

The ways of knowing from a western dominant viewpoint disavow the relationship between the individual and the object being studied (Moodie, 2004; Tarnas, 1998), and carries a foundation created from meritocracy, objectivity and individuality (Bernal, 2002). Clinchy (1996) suggested that a way of knowing that is divergent to the western way of knowing is generally employed by women as opposed to men and is utilized by a connected knower. A connected knower is one who is an ally of the

viewpoint being studied and is interested in understanding the position as well as the method used to derive the viewpoint. Men are more inclined to exhibit separate knowing tendencies in that they approach the topic with a critical and competitive lens, not wanting to understand the method used to arrive at a specific viewpoint. These two orientations tend to create miscommunication and misunderstandings between men and women (Tannen, 1990), and this is evident when examining the environments that are dominated by men, like engineering department atmospheres. According to Clinchy (1996), women and their way of knowing is not conducive to engineering department culture and the men with their dominate way of knowing. This mismatch could negatively contribute to persistence and degree completion of African American women in engineering. Moreover, the Eurocentric way of knowing dominates, producing the pedagogical and educational belief structure used in higher education, which allows White privilege to prevail, thus causing the delegitimizing and devaluing of individuals and knowledge that differs from this western way of knowing (Bernal, 2002).

In summary, the overarching CRT model (Delgado & Stefancic, 2001), along with the undergraduate socialization (Weidman, 1989) model will be used as the conceptual framework that guided my study through a participating “ways of knowing” lens (Rendon, 2009), because I understand the subject matter through my own experience in an engineering academic environment and believe to have some knowledge on the subject that will enhance the findings. This “ways of knowing” allowed me to examine

experiences of African American women in engineering as they themselves experienced persistence in an engineering academic environment. This research has also broadened and deepened my understandings and beliefs about the engineering academic environment.

Undergraduate Socialization and Critical Race Theory

Weidman's (1989) Undergraduate Socialization model (Figure 2) provided the foundation that guided this study examining African American women in engineering as they experienced participation and persistence in an engineering academic classroom. The socialization process occurs, whereby the student:

> (1) enters college as a freshman with certain values, aspirations and other personal goals; (2) is exposed to various socializing influences while attending college, including normative pressures exerted via (a) social relationships with college faculty and peers (b) parental pressures, and (c) involvement with non-college reference groups; (3) assesses the salience of the various normative pressures encountered for attaining personal goals; and (4) changes or maintains those values, aspirations and personal goals that were held at college entrance. (p. 301)

This model suggests undergraduate women in engineering are socialized in a manner that could assist with or hinder successful academic persistence and degree completion. As an example, socialization where persistence occurs could stem from the

engineering department's epistemology that fosters a purposeful learning environment, offered by engaging and supportive faculty (Pascarella & Terenzini, 2005), and linked to policies, procedures, and a pedagogy conducive to academic achievement (Kuh, 1995). On the contrary, engineering department and faculty socialization could have a negative effect on the student, making it more challenging to persist.

There are numerous undergraduate socialization factors that are important for my study. These factors are: student background, parental expectations and pressures, culture of the academic environment, epistemology and pedagogy of the institution and engineering department, student-to-student relationships, and faculty-to-student relationships. The student's background, parental expectations and pressures are important to examine because these factors provide socialization characteristics developed prior to college experiences. The culture and climate of academic atmospheres is an essential element to examine because it helped to determine how students experience, interpret and react to college environments, which has an obligation and responsibility to positively affect the students' academic success (Weidman, 1989). The epistemology of the institutions' and departments' administrators and faculty is important because these policies and procedures could influence pedagogical practices used in the engineering department. These pedagogical strategies could either hinder or assist the persistence of African American students, depending upon their way of knowing strategies (Schon, 1995).

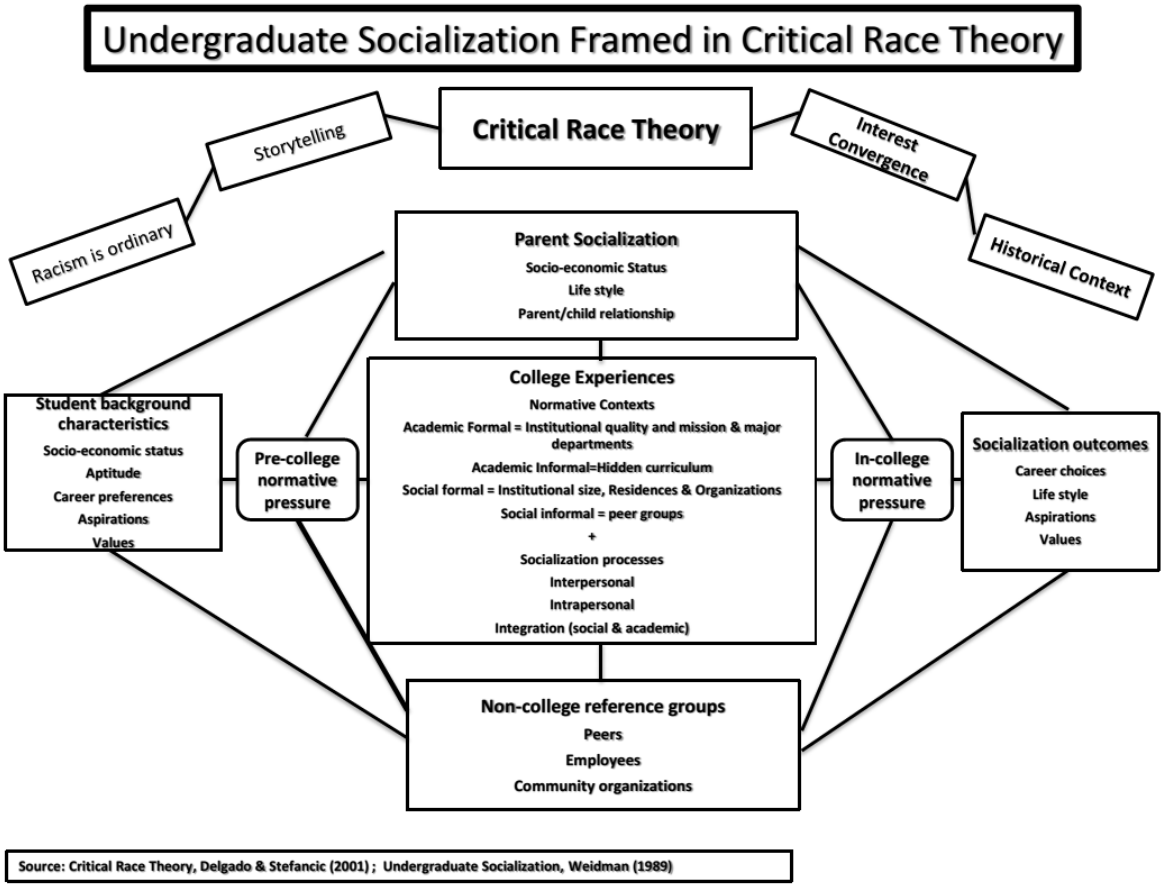
Another dynamic that is vital to this study is the fact the women participating in the study are achieving academic success while experiencing undergraduate socialization at PWI's, whether positive or negative. This examination of experiences had by African American women in undergraduate engineering programs is significant because this information will provide insight into transformational policies and procedures needed in STEM education. This transformation will contribute to the increase of underrepresented students, like African American women, in engineering programs.

To further inform my study, the CRT anchored undergraduate socialization conceptual framework provided a structure by which to examine the experiences of African American women in engineering, who are successfully persisting toward graduation. First, CRT allowed me to examine the undergraduate socialization process through the voices, storytelling and experiences of the study participants. Second, CRT emphasizes racism as normal and this notion was a necessary ingredient in a study focused on African American women in engineering as a result of the racial challenges they encountered.

Third, CRT focuses on the importance of the historical context of a given situation. In this analysis of African American women and their experiences in engineering one should consider the reality that African Americans have been discriminated against throughout history due to their race and women have been discriminated against due to their gender. These two actualities were contemplated as I

examined African American women participating in this study. Finally, interest convergence deserved consideration as the US and companies as a whole begin purposefully including and supporting underrepresented groups, like African American women in various environments, like STEM fields. On the surface this invitation to participate could be viewed as one of inclusion and equity. However, one could argue that underrepresented people are being sought out because US governmental agencies believe that the US is lagging behind other countries as it pertains to a growing STEM workforce, concluding that underrepresented groups are being pursued to fill a void and are needed to help the US continue competing successfully within the STEM environment. In this instance, interest convergence is the coming together of the inclusive equitable act of increasing underrepresented groups in STEM with the need to increase the US STEM workforce.

Figure 2 Undergraduate Socialization Model Modified to include Critical Race Theory



CHAPTER 3

RESEARCH METHODOLOGY

This chapter contains the methodology and methods I selected to ascertain meaning-making of African American women as they interpreted their experiences as engineering students in academic environments. The chapter begins with an introduction of my worldview followed by a discussion of my role as the researcher. The remainder of the chapter details my selection of interpretive phenomenology as the methodology and the methods used to select participants, gather other pertinent information and analyze information. This chapter concludes with the matter of trustworthiness.

Researcher's Worldview

According to Guba (1990), a worldview or paradigm is "a basic set of beliefs that guide action" (p. 17). I believe that an individual's experience and context by which they interpret these experiences are important in order to determine how to best support them. I also believe researchers should not assume all underrepresented racial and ethnic groups or all women have the same experiences and thus need the same support. With these beliefs, I have selected a social constructivist lens to view my interview and analysis data

through. I also examined experiences of African American women in engineering by relying heavily on their views and perceptions. Research performed in a social constructivist paradigm focuses on particular context and experiences that participants engage in on a regular basis (Creswell, 2007). This context and evaluation allowed me to better understand historical and cultural environments from which the participants originate. The acknowledgement of this background information provided me the additional contextual interpretations of the participants' past experiences obtained through interview questions. Finally, the social constructivist worldview supplied me with the ability to recognize study participants' past experiences, realizing that these experiences help to shape their interpretations of present experiences (Creswell, 2007). With this worldview in mind I described my role as researcher, defined interpretive phenomenology and provided the rationale for its selection for this study.

Researcher Role

In my role as a researcher, I aim to contribute to research literature focused on African American women in engineering and their lived experiences while they persist toward degree completion. Interpretive phenomenology has allowed me to insert my voice into the research as I interpreted experiences of African American women interviewed. As a first generation low-income African American high school girl who excelled in math and science, I was encouraged to enroll in an undergraduate engineering

program. During college, I experienced first-hand the challenges facing African American women and other underrepresented populations in engineering. My motivations and self-esteem were developed during my undergraduate college experience, and I was motivated by trying to outperform my peers, not by purposefully mastering the material being introduced. I had this motivation because faculty members and some administrators questioned my presence in the classroom and in the engineering program, suggesting that I study a non-science major. Due to this awareness, I worked extremely hard to succeed, not necessarily to master the material (even though this was important), but I worked hard to earn respectable grades. The engineering environment I encountered on a daily basis was extremely competitive, chilly and unwelcoming and I wanted to prove to the faculty, students and myself that I could perform well.

Within this environment, performance was more important than actually understanding the material, and due to the extremely challenging freshman year workload, my self-esteem was tested as I questioned my academic preparedness and my ability to succeed. I experienced many of the barriers frequently experienced by racially and ethnically underrepresented women in engineering. These barriers are described in the literature as microaggressions (Solórzano et al., 2000), stereotype threat (Steele & Aronson, 1995), the weed out process (Seymour & Hewitt, 1997) and intersectionality (Collins, 1990). My experiences helped to define how I viewed the education process as an undergraduate student and how I presently view it as a doctoral student and scholar-

practitioner. I finally understand that there were cultural differences as well as systemic institutional forces, and not my academic preparation that challenged my persistence. These factors have led me to select this topic for my dissertation research because it is important to understand how successful African American women in engineering interpreted their success as they persist toward degree completion.

Phenomenology Definition and Rationale

Phenomenon, constructed from phaino, means "bring to light, to place in brightness, to show itself in itself, the totality of what lies before us in the light of day" and phenomenology as a methodology has allowed me to expose and "bring to light" African American women and their experience by way of their narratives and voices (Heidegger, 1977, pp. 74-75). Phenomenology is a qualitative research methodology that enables the researcher to make meaning of a phenomenon that is experienced by several individuals, while also describing the commonalities of these experiences (Creswell, 2007). The emphasis of what it means to be, describing experiences and the meaning of these experiences, within a specific context, illustrates philosophical and methodological phenomenological inquiry (Mulready-Shick, 2008). Creswell (2007) concurs and posits that phenomenological studies "describe the meaning for several individuals of their lived experiences of a concept or a phenomenon" (p. 57). In phenomenology, the researcher is concerned with understanding human behavior from the individual‘s personal belief

system (Bogdan & Taylor, 1998). Phenomenological methods and data sources such as open-ended questions, dialog, personal documents, and archival data provide information that focuses on these concerns (Bogdan & Taylor, 1998).

Hermeneutic Interpretive Phenomenology

The term hermeneutic results from the Greek god named Hermes, who was responsible for interpreting messages for the other gods (Thompson, 1990). Hermeneutic or interpretive phenomenology does more than just describe the essence of the phenomenon. Instead, it goes further to explore the human experience rather than just what the individual consciously knows (Solomon, 1987). Interpretive phenomenology follows the notion that the phenomenological inquiry should be the focus of the relationship between the individual and the lifeworld (Heidegger, 1927:1962). The lifeworld is used to express the reality of an individual as he or she is impacted by the environment in which he or she operates. Heidegger (1927:1962) suggested that humans cannot disconnect themselves from the world in which they operate, thus the inquiry of a phenomenon consists of the individual's experiential narrative, which is the definition of being-in-the-world. Heidegger (1927:1962) also stated that individuals experience situated freedom (Leonard, 1999) which allows them to be deeply entrenched in the world, to the point where independent experiences are linked with various contexts such as the social, cultural and political contexts. In these instances, individuals, such as

African American women in engineering, interpret the context in which they are experiencing to then make choices. This concept of situated freedom, (Leonard, 1999) suggests that individuals are free to make choices; however, their freedom of choice is not without influence from the world in which they reside. Furthermore, freedom is accompanied by a profusion of choices (Heidegger, 1927:1962); yet, outcomes associated with choices are not clear due to the world's influence. With this uncertainty the individual must make a choice and then act on the decisions made (Solomon, 1987).

According to Heidegger (1962:1975), hermeneutic interpretive phenomenology focuses on the meaning in a phenomenon with the purpose of understanding human experiences. This interpretive phenomenology focus is a needed progression away from descriptive phenomenology because descriptive effects do not allow for the meaning to be exposed (Osborne, 1994). In conjunction with Heidegger's definition, Cristi and Tanner (2003), Gadamer (1976), and Polkinghorne (1983) conclude that the philosophy of hermeneutics underpins the discipline of interpreting the meaning and experiences of human populations. This process of meaning-making is not a static process and can proceed through iterations (Crist &Tanner, 2003). Due to the interpretive component, the manner in which people are in the world is the focus of investigation, rather than the development of a general theory or calculation of a phenomenon (Crist & Tanner, 2003) and this produced conclusions obtained specifically through the voices of specific participants of my study.

Influential factors in this interpretive process is the researcher's presuppositions and knowledge because the researcher's knowledge and preconceived notions provide value to the analysis and can create a more meaningful inquiry which is why I discussed my worldview and role as a researcher. Furthermore, Heidegger (1927:1962) thought it impossible for a researcher to disavow his or her knowledge and that the researchers' knowledge and assumptions are necessary for interpretive phenomenology, concluding that research is a combination of input from the study participants and the researcher. Gadamer (1976) used the phrase "fusion of horizons" in order to explain "the act of intersubjectivity, understanding, and interpretation" (Lopez & Willis, 2004, p. 730). The horizons are developed through the assumptions, experiences, meanings and ideas that an individual possesses, and these contexts change in accordance with circumstance, history and world occurrences (Lopez & Willis, 2004), concluding that there cannot be one true meaning that is produced from an interpretive study because findings will reflect realities of study participants and will comply with the conceptual framework applied to the study (Annells, 1996).

To that end, this study is partly my story and has become my life's work and this is one reason I selected phenomenology, particularly interpretive phenomenology, as my research strategy of choice. Interpretive phenomenology is the most appropriate qualitative methodology for the exploration of African American women engineers as they make meaning of their experiences while persisting toward degree completion.

Further, this research strategy allowed me to continue questioning the phenomenon and its associated analysis as well as question and alter my position on the subject matter, while listening to the participants make meaning of the phenomenon and their reality within it. I selected this methodology because it provided a mechanism to obtain a more substantial understanding of African American women in engineering undergraduate programs and their experiences as they persist in an engineering discipline because information gathered and the way in which it was gathered is rich with the voices of these women.

Methods

This section of the study emphasizes the sites and participant selection processes. It also addresses data collection; consisting of interview data and institutional information. Once the data collection process has been discussed, data analysis and trustworthiness verification is examined. Finally, I discuss the manner in which my conceptual framework informed my data collection decisions and data analysis.

Site Selection

Five private institutions located in the Northeast of the country were selected for the study. These institutions were selected because of their engineering school rankings and the fact that the engineering schools are selective during their admissions process.

This high selectivity will suggest that all students chosen for these engineering programs have the aptitude to persist and graduate with an engineering degree. It was also important to select institutions that are in the same vicinity and that provide support for underrepresented populations in STEM majors. Selecting institutions in the same vicinity provided the opportunity to determine if institutions in the same geographic area provide similar experiences. Additionally, the support initiatives and programs conducted within each institution could be viewed as significant factors in the experience of the African American women who participate in the study.

At the time of the study, these institutions were ranked by U. S. News and World Reports as having one of the top 100 best engineering schools in the US, or top 20 regional colleges and are within 70 miles from each other. These institutions purport to have developed some of the best engineering programs in the country and are recognized for these programs due to their ranking status. These engineering schools implemented initiatives and programs created to support underrepresented students in the various engineering majors. These programs contribute to the experiences of the women who participate in the study.

All five institutions are PWIs. PWIs were specifically selected because they are the focus of most engineering education research pertaining to underrepresented populations and this environment tends to be where underrepresented students, like African American women in engineering, have the most challenges both academically

and socially. This is particularly evident when research concludes that HBCUs produce most of the country's STEM African American graduates (Borden & Brown, 2004; Perna et al., 2009). Anonymity was provided to each institution through the use of pseudonyms. These pseudonyms were used for the duration of the study.

Description of the Engineering Schools

For the purposes of this study the engineering colleges will be referred to as: Upper College, Lower College, Center College, Middle College and Inside College and their context is described below.

All of the colleges offer B.A, B.S, M.S and Ph.D. degrees. The institutions range in learning style. Some institutions describe their curriculum as being built around collaborative project-based learning combined with a strong theoretical base, while others focus on innovation, technological leadership and interdisciplinary research, providing a high quality education by using workforce experience as a purposeful ingredient, with commitment to diversity, equity for and inclusion of traditionally underrepresented groups in engineering and project based learning that is collaborative and interdisciplinary.

In 2014, the combined student SAT scores for each institution ranges from 1497 to 2300, placing each institution in the 75th percentile ranking. Each institution enrolled a number of African American women in engineering programs totaling 103. Support

organizations such as the National Society of Black Engineers and the Society of Women Engineers are active and thriving organizations on all five campuses to support African American students and women.

Study Participant Selection

The criteria used to select interview participants for this analysis is defined as follows: an African American woman who was classified as a junior or a senior in an engineering discipline at the time of the study, and who was on track to graduate in four to five years as determined by their institution. Eligibility to participate in the study was determined when the women answer three questions: (1) Do you identify as an African American woman (2) is engineering your major and (3) are you a junior or senior on track to graduate on time as defined by your institution. If the answers to all three questions were yes, then the women were invited to participate in the study. If any answer to the questions were no, then the women were thanked for their time and informed that they did not fit the eligibility for the study (Attachment 3).

According to Polkinghorne (1989), interviews should be conducted with between five and twenty-five participants for a phenomenological analysis. This range acted as a guide and African American women in engineering undergraduate programs were interviewed until saturation was reached whereby the themes began to repeat themselves. Sixteen women were interviewed for the study, having the lived experience in an

undergraduate engineering program as either juniors or seniors. At the time of the study, participants were traditional in age, with ages ranging from 21 to 24 with GPAs ranging from 2.3 to 4.0 (Table 8). All of the women were on track to graduate on time per their institution. The women were all purposefully selected and introduced to my study by either, faculty members, deans or multi-cultural center staff members within their respective institutions (Merriam, 2009).

Participant Recruitment

Engineering faculty and administrators were asked to introduce the study to their students to determine if any of them would be interested in participating in the study (Attachment 1). The faculty and/or administrators were also asked to obtain email addresses of the women who were interested in participating in my study. I then contacted potential participants via email to introduce research details and to discern their interest level and eligibility (Attachment 2).

All women participated in the study voluntarily and completed all necessary IRB consent forms. Participants were required to sign both documents (Attachments 4 & 5). At any given time during the interview process, the participants were able to end their participation in the study. Homogeneous sampling was used for this qualitative analysis, along with criterion sampling to ensure that one racially homogeneous population, African American women, was selected with the specific major criterion of engineering.

Pseudonyms were created for study participants enabling their voices to appear in the study without exposing their real identity. Study participants were asked to create their pseudonym at the beginning of the first interview and this identifier was maintained throughout the research process.

Data Collection

Two activities occurred during data collection: institutional documentation gathering was conducted first and interviews followed. Interviewing protocols were designed for this research project and were submitted to University of Massachusetts Boston's Institutional Research Board (IRB) for approval. Once University of Massachusetts Boston IRB approval was obtained, I contacted prospective school administration, faculty and study participants. Interviews were audiotaped with the participants' consent and were sent to a third party, named Reve.com, for transcription.

Institutional documentation. Institutional and departmental documentation was gathered and explored for context and to obtain a better understanding of the institutional and engineering department environments experienced by African American women. Documents included institutional mission statements, engineering department and program documentation and data on the persistence and graduation rates of African American women for each institution. This additional information was important to the

phenomenological analysis because it provided a more robust depiction of the environment the women experienced, allowing me to better interpret the meaning they made of their lived experiences.

Interviewing. During the interviewing process, a semi-structured protocol was followed (Creswell, 2007) (Attachment 6). The interview questions were semi-structured and open-ended allowing a conversation to occur (Creswell, 2007). By way of the interviews, I sought to understand perceptions held by African American women as they reflected on and gave voice to their experience as engineering students. With these interpretations, common themes arose. Interview sessions lasted between one hour and one and one half hours and were conducted in a mutually agreed upon location that allowed for privacy on or off campus depending on the request of the participant. Participants were asked to commit to two interview sessions. During the first interview predetermined interview questions were used to guide the interview, focusing on the participants' family support, educational background and the undergraduate environment they were presently participating in along with their engagement with faculty and peers. Once the first set of interviews were completed and analyzed, areas in the interview data that required clarification were examined. As additional information was needed, further interviews were conducted, via video chats and phone calls. If further questioning was needed email was used to obtain clarity and re-address specific topics associated with various

questions. Additional questions were derived from information received from the first interview that required further investigation and interpretation. Approximately 30 hours were spent listening to and communicating with the study participants as they continued to tell their stories.

Data Analysis

The hermeneutic, interpretive methodology based on Cristi & Tanner's (2003) analysis process was used and followed throughout this phenomenological examination as I interviewed African American women in engineering and analyzed interview transcripts to generate themes and patterns (Ironside, 2005). Themes, differences and commonalities discovered from these data were analyzed along with college and departmental documentation. Cristi & Tanner (2003) outlined the hermeneutic phenomenology analysis process as consisting of five phases: (1) early focus and lines of inquiry; (2) central concerns, exemplars, and paradigm cases; (3) shared meaning; (4) final interpretation; and (5) dissemination of the interpretation (pp. 203-205). To assist with data analysis I used a qualitative analysis software package, named Dedoose. This tool enabled me to compile all interview data into one database where I was able to manipulate the data into categories that guided the coding process for this study.

I analyzed institutional documentation to obtain a better understanding of engineering schools environments. I looked to determine the type of support each

institution provides their engineering students and if there were organizations that supported African American students and/or African American women. I also analyzed data describing the representation of African American women in the engineering school, the number of African American women enrolled in the engineering school as well as the number of graduates in 2014. Reviewing the college and/or engineering schools' mission statement provided me with an insight as to the importance of the learning environments and diversity.

Next, I reviewed interview transcripts, allowing for the interpretive process to begin, and also to determine if a second interview was required; this was when initial coding began. In phase two, concerns, themes, and meaning were developed through the initial interpretation process. The "concerns" was information that required further exploration and understanding by me or from the study participant. In this phase "the goal was to understand the way the person is oriented meaningfully in the situation" (Benner, 1994, p. 105). This understanding was obtained through the process of writing and rewriting the formulated concerns in an iterative manner. To further bring forth the interpretations, I used exemplars, which are significant and poignant excerpts of the various interviews. Once concerns and exemplars were preliminarily established, the dialogical process of "naming" occurred, whereby themes were named, leading to conceptualization of central themes (Dreyfus, H., Dreyfus, S., & Benner, 1996).

Phase three consisted of discerning the shared meanings offered by the participants' concerns. In this process the connections between and across the participants' stories became more apparent through the interpretations of the central exemplars and concerns. I accomplished this by establishing specific themes for each interview participant and then analyzing themes to determine where central themes, exemplars and concerns exist. In phase four, the second sets of interviews were conducted, if needed, allowing for more focused interpretations of interview data. The final and fifth phase encouraged me as the researcher to further the interpretation process by reviewing interview transcripts, notes, iterative and interpretative notes in order to develop the final interpretation. These stages are akin to the hermeneutic circle of understanding, a process used to allow for continuous interpretation and movement between parts of an experience and the entire experience (Annells, 1996; Polkinghorne, 1983), whereby an increased amount of understanding and interpretation is ever present (Jost, 1997). The hermeneutic circle of understanding enabled me to engage and connect all understandings both past and present (Heidegger's, 1927:1962).

Trustworthiness

In phenomenology, trustworthiness of information and its interpretation is important. Trustworthiness provides verification of the research process through a constructivist lens (Morrow, 2005). As described by Sandelowski (1993), trustworthiness

“becomes a matter of persuasion whereby the scientist is viewed as having made those practices visible and therefore auditable” and this auditability of the analysis is the “process of leaving a decision trail,” (p. 2) which enables the reader to follow and verify the researcher process.

Lincoln and Guba (1985) present four questions pertaining to trustworthiness. How does the reader know: (1) to have confidence in the findings; (2) the degree to which the findings apply in other contexts; (3) if the study could be replicated in the same manner; and (4) the degree to which the findings emerge from the context and the respondents and not solely from the researcher (Lincoln & Guba, 1985)? To respond to these inquiries, I have provided sufficient and credible interpretations of the phenomenon being researched that relay the meaning-making of the engineering academic experience as described by African American women. I know that the interpretations are credible because I have asked the study participants to review the transcripts for inscription accuracy as well as my interpretations to ensure that the interpretations represent their experiences and are sound. I have also compared interview transcript to the interview audio tapes to ensure integrity of the specific narrative of each study participant (Cristi & Tanner, 2003).

Conceptual Framework

The conceptual framework (Figure 1) consists of Weidman's undergraduate socialization model with an overarching CRT lens. This framework informed my study in several ways. First, the undergraduate socialization model enabled me to examine experiences of the study participants. These experiences along with the manner in which they were interpreted provided context to the college socialization process. Second, the overarching CRT model ensured that the CRT tenants: racism is normal, interest convergence, the importance of historical context and the unique voices of color were considered and implemented during the undergraduate socialization analysis. The combination of the CRT tenants and the undergraduate socialization model was used to create the study's interview questions. The framework also directed the manner in which I analyzed and interpreted the data. During the analysis, I incorporated the undergraduate socialization model focus that was applicable to specific datum and then considered each CRT tenant for viability.

Limitations

This study had depth and breadth; however, there are limitations. The study was only conducted at five institutions that were in a 70 mile radius of one another. This proximity was useful because the social climate of the area would be a good barometer of the campus climates. There also could be an argument that the close proximity could lead

to similar environments. In contrast, women from additional institutions, located in different areas of the country, could have provided other evidence that did not emerge from the women representing the five institutions.

A second limitation of my study was the breakdown of the majors studied by the women. Six women studied mechanical engineering, four women studied chemical engineering, two studied biomedical engineering, and one woman each studied civil engineering, industrial engineering, computer engineering and engineering. The over representation of mechanical engineering and the under representation of majors focusing on civil, industrial, computer and engineering did not present a balanced depiction of engineering majors.

CHAPTER 4

FINDINGS

INTRODUCTION OF NARRATORS AND CORE THEMES

This chapter and the next introduce the sixteen women in this study along with the themes that emerged and from their narratives as they made meaning of their academic experiences. These experiences entail interactions within the engineering academic environment with peers, faculty members and administration. The women storytellers participated in weaving together a tapestry of experiences at various engineering colleges.

Introduction of African American Women and their Voices

Aisha, a senior studying mechanical engineering at Upper College, is from a northeastern state and was 23 years old at the time of the study. She had her sights set on engineering for a long time. As a child, she worked on projects with her father, who is a welder and mechanic, and she became interested in the sciences. She applied to participate in a science program and focused on math and science throughout high school. She received a great deal of support from her family including her aunt who worked at a

research center and would assist Aisha with science projects. Once in college, Aisha focused on mechanical engineering.

Brandy, a junior at Upper College, is from a northeastern state and was 21 years old during this study. In high school, she participated in AP physics, AP calculus and AP chemistry classes, and these subjects led her to her interest in engineering. While in high school, her physics teacher's goal was to develop engineers and this idea of being an engineer motivated Brandy. With this interest in engineering, Brandy focused on civil engineering during her freshman year at another institution. After her freshman year, she decided to transfer to Upper College, where she switched to a major in chemical engineering.

Saran, a 23 years old senior from a northeastern state, was most interested in math due to her mother's support and encouragement. Additionally, she attended a boarding high school and had a math teacher in her last two years who encouraged her to focus on math. She enjoyed physics and building things with her hands. As she began to ponder a college major that could incorporate the two, she thought of mechanical engineering. She selected Center College because it offered mechanical engineering. Prior to freshman year she participated in a program that introduced college life and engineering courses to entering students. She described it as being a good support network and a place where she received motivation.

Kelsey was 21 years of age and a junior at Middle College at the time of the study. She is from a northeastern state and participated in a Saturday engineering enrichment program that introduced her to many engineering disciplines. Her high school math teacher recommended her for the program and encouraged her to attend. Kelsey's interest in engineering grew as she participated in the enrichment program throughout her four years of high school. She was particularly drawn to mechanical engineering. However, she still enjoyed business and decided to combine the two disciplines, majoring in management engineering, out of the business college with a concentration in mechanical engineering from the engineering college.

Jasmine is from a northeastern state, was a junior and 22 years old at the time of the study. She was introduced to engineering through a program she participated in from eighth grade until eleventh grade. The program introduced her to engineering through many hands-on projects and she came away interested. However, Jasmine excelled in English and history and her high school did not have as strong math program. Jasmine was still interested in engineering even though her high school did not focus on math or science so she enrolled in Upper College, majoring in mechanical engineering. She attended the pre-college program that introduced students to each other and to the engineering curriculum. Jasmine thought the work was difficult, but she persevered. The summer program presented her with a network and a strong support mechanism.

Serena, a senior, was 20 years old during the study and arrived at Upper College from a northeastern state. She was very science focused in high school, particularly in chemistry. She appreciated her chemistry teacher because he was strict and motivational. Serena did not declare her major immediately upon entering Upper College because she did not know what she wanted to focus on. However, her major became clear as she began taking chemistry and biology courses. She was drawn to chemistry, once again because of her professor. As she made the connection to chemical engineering she knew that this was the degree she wanted to pursue.

Jordan from a southeastern state was 22 years old and a junior at the time of the study. Math and science were always two of her strengths. Prior to college, she participated in STEM outreach programs and thought that construction engineering was interesting. She wanted to pursue a degree that would enable her to secure a job. In high school, Jordan took an AP physics course by correspondence during her senior year. Jordan enjoyed the class and excelled at it. This was the class that directed her towards engineering as she left her high school as valedictorian of her class. Once she entered Upper College and began her coursework, she had to decide between electrical engineering and civil engineering as her major and decided to focus on civil engineering.

Ruby came to Central College from a northeastern state. She was 21 years old and a senior during the study. She attended a private boarding school, where she did not board, but she stayed at school for longer hours compare to a traditional New York public

school. She felt like she was never home. In high school, she always participated in science courses such as AP physics, AP biology, chemistry and AP calculus. With the exposure to these courses she excelled in math and science as compared to history and English. Her mother suggested engineering for her college major and even though Ruby did not know what engineering was, she applied and was accepted to Central College. She started her college experience with a summer program that allowed her to get acclimated to the engineering school, some of her peers, faculty members and courses. She decided to pursue a bachelor's degree in engineering.

Heather is from a northeastern state, was 20 years of age and attended Middle College as a junior at the time of the study. She attended a private high school where her teachers were very involved with her learning process. She was interested in physics, anatomy and physiology. She described her teachers to be exceptional and this helped Heather grasp the material. Heather's parents are engineers and they both supported her and her education. She selected bio-medical engineering because she wants to become a doctor, but still wanted to keep the option of being an engineer open, so bio-medical engineering provided her the best of both disciplines.

Lola was a junior studying industrial engineering at Middle College, and was 20 years old at the time of the study and is from a northeastern state. She selected industrial engineering because she wants to combine business and engineering enabling her to work in a technical environment as well as understand business management. Lola's degree is

offered out of the business school. In this scenario, she participates in engineering courses as well as business courses. She has always excelled in math and science and participated in AP and college courses while in high school. She loves to learn and is also interested in history and geography. She is very community focused and believes in the importance of giving back to her community as they have given to her. Her interest in engineering was solidified when her community sponsored her to an engineering conference.

Nicole was 21 years old when she participated in the study. She is from a northeastern state and attended Upper College as a junior studying chemical engineering. She was always interested in science but the idea to pursue chemical engineering came about as Nicole participated in AP chemistry classes in high school; it was her favorite class. Additionally, Nicole liked her teacher who was instrumental in guiding her to chemical engineering. She did not know what an engineer was, but her teacher and others thought she should pursue engineering because of her interests. She selected Upper College because it offered her the opportunity of work experience in her field.

Mary was 20 years old, from a northeastern state. She was a junior at Upper College studying mechanical engineering at the time of the study. She had her first experience with engineering in middle school when she participated in an introductory engineering program. She participated in similar programs as she got older and was exposed to computers and basic programming. Her father was interested in computers

and he passed the interest on to her. She is now able to program a computer to do a great many things. In high school, she participated in algebra, pre-calculus and calculus courses at the local community college. As she participated in these classes in high school, she knew she wanted to be an engineer. At first, she wanted to focus on computer science, but ultimately wanted to focus on physical aspects of science and this led her to mechanical engineering.

Skyler is from a northeastern state and was 24 years old during the study. She studied mechanical engineering and is a senior. She became interested in engineering at an early age. She always enjoyed building things and math came easy to her as compared to other subjects. Additionally, she loved art and described engineering as art through numbers. As she continued with math in high school and beyond it became more challenging than she thought but she persevered because she enjoyed it a great deal. She selected Inside College because she was able to transfer there from her previous institution and the college had the major she wanted to focus on.

Lisa is from a northeastern state, was 21 years old and a junior during the study. In high school she was interested in math, pre-calculus, chemistry and AP-chemistry. Her interests in the sciences started in elementary school. She really enjoyed math and was motivated to improve her skills. She also enjoyed assisting her classmates with math. Besides the support of her parents she also had a high school math teacher who supported her math interest. Lisa honed in on engineering because she was excited about the

problem solving aspect of engineering and thought that an engineering degree would provide her with security as she entered the workforce. She participated in AP-chemistry and was more interested in chemistry as compared to other engineering disciplines. With this notion she selected Upper College because it provided the chemical engineering program she desired.

Simone was a 20 years of age junior from a western state at the time of the study. Her arrival to college was her first trip to the east coast. Since elementary school, she has enjoyed taking things apart and seeing if she could rebuild them. In high school, she joined the computer club and this sparked her interest in coding. She began taking calculus and sciences courses and determined that she liked math. She was also on the debate team as well as the school newspaper. She enjoyed writing and this activity sparked her interest in technical writing. She continued challenging herself and while in high school enrolled in technical classes at a vocational school and this is where she met an advisor who directed her towards engineering as a college major. In her senior year of high school she received her computer technician certification and this is what solidified her goal of becoming a computer engineer. She selected Upper College because it offered computer engineering and supplied her with a good financial aid package.

Susan is from a northeastern state and was 22 years of age studying bio-medical engineering at Lower College as a senior during the study. She was introduced to STEM at an early age while participating in various STEM programs throughout her K-12

experience. In high school, she attended an institution with a science focus and during this time her interest was medicine. In college she decided to major in Bio-medical engineering, which allowed her to explore engineering as well as the medical fields. Susan believed that the bio-medical engineering degree provides her with options.

The stories these women tell are personal and will show first-source accounts of their college experiences. These women range in age from 20-24 years and have GPAs ranging from 2.3 to 4.0, which averages to a 3.2 GPA. They originate from various states and together, they attended five PWIs: nine women from Upper College, three women from Middle College, two women from Center College, one woman from Inside College and one woman from Lower College (Table 8).

Most of the women interviewed grew up in a middle class socio-economic family. The women interviewed have parents with professions such as pharmacist, CEO, radiologist, production supervisor, health care professional, executive secretary, teacher, mechanics, physical therapists, engineer and medical doctor. One woman described herself as being raised in a lower socio-economic status family. Lola stated: “I came from low income, first gen[eration]”. Regardless of family income, 14 of the 16 women in this study received some level of academic scholarship during their undergraduate engineering experience. For instance, Simone was very satisfied with her financial aid package as she stated: “Honestly, they [the institution] were wonderful with the financial

aid". Additionally, Lola expressed that "they [the institution] gave me the best financial aid package, so pretty much; I get money back from them [the institution]".

In all of my conversations, no matter what the socio-economic situation, parents were actively involved in their children's educational path and pushed the women to be educated, self-sufficient individuals and in specific cases the women were pushed to become engineers. All of the women in the study welcomed the encouragement.

Table 8 Participant Demographics

	Age	Engineering Major	Year	College
Aisha	23	Mechanical Engineering	Senior	Upper College
Brandy	21	Chemical Engineering	Junior	Upper College
Saran	23	Mechanical Engineering	Senior	Center College
Kelsey	21	Management/ Mechanical Engineering	Junior	Middle College
Jasmine	22	Mechanical Engineering	Junior	Upper College
Serena	20	Chemical Engineering	Senior	Upper College
Jordan	22	Civil Engineering	Junior	Upper College
Ruby	21	Engineering	Senior	Center College
Heather	20	Biomedical Engineering	Junior	Middle College
Lola	20	Industrial Engineering	Junior	Middle College
Nicole	21	Chemical Engineering	Junior	Upper College
Mary	20	Mechanical Engineering	Junior	Upper College
Skyler	24	Mechanical Engineering	Senior	Inside College
Lisa	21	Chemical Engineering	Junior	Upper College
Simone	20	Computer Engineering	Junior	Upper College
Susan	22	Bio-Medical Engineering	Senior	Lower College

Introduction of Core Themes

In this section, I introduce themes and their associated sub-themes emerging from the interviews (Table 9). Based on interview data and subsequent analysis, five core themes, along with associated sub-themes emerged. The first theme is "In the Beginning – STEM exposure", focusing on experiences and connections had by the women participating in the study prior to college. This exposure to STEM originated from parental interaction, K-12 STEM activity, and support from teachers. The second theme, "Motivation", emphasizes situations, people and/or opportunities that motivated the women in the study. These motivations originated from their inner goals as well as external sources. These motivations were realized or not as a result of the manner in which the women conducted their learning motivation strategy. The women focused on performing well and obtaining exceptional grades, mastering information and/or by avoiding academic course work when the subject matter was difficult and /or the academic environment was chilly and unwelcoming.

The third theme, "Sense of Belonging," underscores feelings experienced by the study participants as they participated in their academic environment. The women acknowledged varying levels of social and academic integration and this level helped them determine their sense of belonging in any given situation. The fourth theme "Support" highlights assistance received by the women and/or the assistance they did not receive and needed. This support or lack thereof originated from faculty, peers, college

administrators and their home communities. Finally, the fifth theme, “Responses to Racism and Sexism” concentrates on the manner in which these women reacted to their academic environment as it pertained to race and gender.

Table 9 Core Themes and Sub-Themes

Core Themes	Sub-Themes
In the Beginning - STEM Exposure	STEM Interest, Influencers, Making and Building
Motivation	Intrinsic, Extrinsic, Academic Achievement Goals
Sense of Belonging	Academic Atmosphere, Peers, Faculty
Support	Faculty, Institution, Peers, and Community
Responses to racism and Sexism	Internal and External

In the Beginning - STEM Exposure

The study suggests that all of the women in the study had interest and aptitude for a college engineering degree. Whether it was in high school or earlier, these women recognized their own interest and aptitude in STEM related subjects and / or were recognized by parents or teachers as having an interest and ability to excel in engineering, and this recognition was reinforced. At that time in their lives, some of the women did not have an idea as to what being an engineer meant; however, they did know they enjoyed math and science. Once they were exposed to STEM topics their interests focused on engineering. This interest generated the selection of an engineering degree, whereby the degree would be a tool by which they could build their careers.

STEM Interest and Influencers. This section focuses on the women's introduction to STEM. These introductions took on many forms, whether from parents, teachers and/or a general interest in math and wanting to build things.

A Magical Strong Suit that Builds Moving Mechanisms. Most of the women stressed positive interactions with K-12 teachers or in K-12 STEM classes and programs and this study could posit there to be a direct correlation between these factors, their aptitude and their undergraduate engineering degree selection. Nicole, a chemical engineering major at Center College enjoyed science in high school and described how AP chemistry solidified her interest in an engineering college degree. Nicole remarked:

> I always liked my science classes, but I guess my AP chemistry is what made me want to do engineering in college. I loved my teacher. I took her for regular chemistry and AP. I liked the subject, it was interesting to me, and then I was kind of just going to do a chemistry major in college and the teacher is who got me to do chemical engineering.

Nicole's teacher was influential in her interest in chemistry and her focus on chemical engineering as a college major. Jordan, a junior studying civil engineering at Upper College, enjoyed math and science and acknowledged that she excelled in both. She, like Nicole participated in AP classes. Jordan commented:

> I was interested in math and science; it was one of my strong suits. We had a bunch of outreach programs come in and talk about engineering. It seemed interesting. I was interested actually in Construction Management, I thought it was cool. Engineering is a degree where you finish it and you have a job after. I didn't want to go and just get some random degree that would be difficult to make into a career. That's one of the reasons why I picked it. I didn't really take any specific classes. My high school didn't really offer a lot upper level mind science and math classes, but I took AP Physics via correspondence, my senior year and I liked that. That's the last step that led to me actually sticking with engineering.

Jordan searched for a major that would supply her with financial security and her interest in science helped to select engineering. When Jasmine, now a junior at Upper College, attended high school, she did not enroll in any advanced class in math and science, unlike most of the women in the study. Her high school was taken over by the government, due to poor performance, shortly after she graduated. However, she was selected to participate in an extra-curricular STEM program and this was the manner in which she was introduced to engineering. Jasmine stated:

> The whole time I thought a mechanical engineer was a mechanic. I'm like, "I'm just doing this [attending the STEM program] for the free food, and the field trips, and all that stuff." Then I realized, "Oh, so it's basically a human form of a magician. I'm totally into it." Then that's what it was. In high school all my good

> grades were in English and history, so that's the interesting part. Other than that, no, my high school did not at all have a strong math and science background at all.

Even though Jasmine was introduced to STEM during her participation in the STEM program, and had aptitude, she did not participate in advanced math and science classes as compared to ten of the other women in the study and this made freshman year challenging for her. Unlike Jasmine, Kelsey participated in an introduction to engineering program while in high school. Each year the program focused on a specific engineering discipline. The first year focused on mechanical engineering, the second year was aerodynamics, the third year was robotics and the last year was biomedical engineering. From this experience Kelsey selected Management Engineering with a concentration in Mechanical Engineering as her college major. Kelsey's introduction to engineering was more focused and longer than the other women's experiences because it lasted the duration of her high school involvement. Mary, a junior in mechanical engineering at Upper College, was introduced to science by her father and an engineering program in which she participated. Mary described her experience this way:

> I guess in elementary school, my dad had this book called Visual Basic Programming. I took it and I played around with Excel and I learned how to program that way. I like to also program so that's where my programming interest came from. Then the engineering came from [Project Build]. We used Legos and

things to build moving mechanisms. That's my first exposure and where I first got interested in it. I took algebra 1, algebra 2. I didn't take pre-calc and calc in high school. I took it at a community college, but it was in conjunction with my high school. I took web design, AP computer science, and those standard classes.

Most of the women in the study described their various introductions to science, technology, engineering and math. Most of them participated in AP math and science courses in high school. However, Jasmine and Skyler did not express participation in these types of classes in high school and Jasmine went on to say that her high school did not provide these types of offerings. These interactions and opportunities to participate in STEM programs, advanced math and science courses were instrumental in the women's future STEM interest and more specifically in their participation in undergraduate engineering programs.

Legos, Toasters, Computers and Cell Phones. This section presents hands-on experiences that shaped the women as well as their interests in STEM. Some of the women interviewed became interested in STEM because they enjoyed building and/or taking objects apart. Skyler, a senior at Inside College studying mechanical engineering, stated that her interest started when she spent time with her brother and became interested in art. Skyler remarked:

> Ever since I was little, I loved building things…loved Legos, loved boy toys. I was a big tomboy, so I loved my brother's toys basically. He had Connects, Legos, all of that stuff. I loved building things from a young age. Math was a little bit easier for me growing up. Because I got that gratification through being successful in it, but I have to say my love of art brought me to engineering more than that, which is something people don't often think. When I was young my great aunt, she was an artist, we would do all kinds of art projects together and I just loved art. She taught me all those things, screening, it was just really cool to me so when I paired that with my love of building things, to me, when I discovered what engineering was, I saw it as art through numbers.

Skyler enjoyed building and when she connected it to art, her interest in engineering emerged. Simone, a computer engineering major in her junior year at Upper College, had similar interests to Skyler, but rather than building and dismantling Lego blocks she started building and dismantling household items and electronics at an early age. The first item she tried to rebuild was the toaster. She was inquisitive and wanted to know how things worked. Simone described her growing interest this way:

> Since elementary school really, I was one of those kids who would annoy my parents and take things apart in the house just for fun, to see if I could put it back together. Loved it, annoyed them, but it…I learn a lot from that. Then for some reason, I realized that taking apart like computers and calculators and things of

> that nature was a lot more fun than just like a microwave or something. When I got to high school, I joined computer club and that sparked my interest in coding. Well, obviously, I have to take the general courses like calculus and science and I realized that I really like the math and science classes so it's just like another thing. Yeah, I should probably do engineering and get to college.

These two women were introduced to STEM by their interest and curiosity as to the manner in which objects were constructed and how they worked. These women then took their interests of building and translated them into STEM and further into engineering.

An Excited, Supported Superwoman Set on Engineering and Influenced by Family. Lisa, a junior at Upper College majoring in chemical engineering, developed her excitement about math and science in high school. Lisa expressed:

> It was a combination of the excitement of problem solving and not just something mediocre… Problem solving, that's exciting, and also having a better chance of getting a job. That was just my idea of security. I think also curiosity. I'm a person who wants to know how things work and I'd rather be on the end of like ... Instead of just saying, "This machine produces this," I want to know how this machine is able to produce this, which is just a very basic example, so I'd say curiosity. Instead of going straight into mathematics, I just felt like engineering.

Lisa was inquisitive and wanted to know how machines worked. This curiosity propelled her into engineering. Brandy, a chemical engineering major, and a junior at Upper College, expressed her experience by reflecting on her feelings when she participated in AP classes. She, like Lisa, expressed how math and sciences made her feel. Brandy stated:

> I was really on top of the world as a senior in high school. I really thought I was superwoman. I was taking AP physics and AP chemistry and I was doing pretty well within classroom. I was like; I want to be an engineer.

Brandy's desire to be an engineer was more general than Lisa's in that she performed well in her AP course and she liked chemistry. Heather, a bio-medical engineering major studying at Middle College, furthered this sentiment by discussing her interest and love for engineering subjects. Heather commented:

> I went to a private school beforehand and they are very, the teachers are very involved with you, how you really liked the subjects, physics, math all the sciences, pretty much and what I really was interested in was physics and anatomy and physiology class. Those teachers were really great in that subject matter which helps a lot but I also just - it clicked with me…. those subjects. I just found myself wanting to do their homework first, I was not so nervous taking the test, I actually enjoyed taking physics test, a little nerdy but … Yeah; it is kind of in my blood to love engineering.

Aisha, a senior at Upper College studying mechanical engineering, shared the same sentiments as some of the women in that she had already focused on engineering at an early age. Aisha was always focused on engineering as she stated: “I had already set my sights on being an engineer before high school. This goal to become an engineer was sparked by her father who was a welder and mechanic. ” Lisa’s experience was a little different than the other women in the sense that she liked to compete using her math knowledge. She explained that her interest in math was ignited by math competition as well as her ability and willingness to assist others in the subject. Lisa reflected:

> I'll say even as far back as elementary school. I think the competition aspect of math is what got me excited, and finding out that I was good at it also helped me. I think my first memory of being good at math was when my mom [and I]…would do math equations together and I'd just try to see how fast I could go through the flashcards that she'd give me, and then even as far back as third grade we would have the one-minute timed math multiplication test and I'd try to be the first to complete everything. It was just me and the others who were kind of back and forth so I think even from ... Just helping my ... If someone else didn't get it and I was able to explain it to them it just helped me like it more, because you know, the good feelings of helping somebody or being good at something, being better at it than someone else, makes me associate positive feelings with the subject.

Susan, unlike Aisha or Heather was influenced by her older sister who was involved in STEM and this solidified her interest after she participated in a STEM program. Susan remarked:

> I also was a part of the STEM program for a University called [STP], which is [Science and Technology Program]. They emphasize science and try to make sure minorities go into these fields and such. Taking the science classes there, there was a teacher who was actually like, "Yeah, Science!" And I was like, “Oh, Okay, This stuff is cool." My oldest sister was involved in sciences. I looked up to her so I was like, "Oh, Okay! Cool! Science!" Just being exposed to it and seeing what you could do with science has made me more interested in it.

Susan was exposed to STEM through the STP program but her interest was heightened because of her sister’s involvement in science.

Positive teacher interactions were also evident throughout the narratives. More generally, the women discussed their involvement, interest and positive participation in math and science courses and program. Excitement and feeling like “superwoman” epitomized positive experiences these women felt while interacting in STEM environments. The women in the study had opportunities to explore STEM subjects in or prior to high school and these experiences and positive interaction with teachers helped to shape their college decisions. As the women brought forth their narratives, it became evident that these experiences were significant factors that positively influenced their

decisions to focus on engineering as an undergraduate major. The foundation of these experiences originated from the detail that most of women enjoyed and excelled in math and/or science. One could also infer that interactions between the women and their teachers were positive and that these interactions were components of their positive experiences.

Pressure: A Conference, Neighborhood Peers and a Sub-Par Education. All of the women in the study experienced pressure to perform academically in college. However, three women talked about some challenges and pressures prior to college that helped to shape how they viewed college and their education.

Lola, a junior in industrial engineering at Middle College, for example, was raised in a low income environment and was confronted with the prospect of not being able to attend an engineering conference causing a great deal of pressure for her and her mother. However, Lola's community partnered with her and raised funds for her to attend a STEM conference. This trip experience was influential in her decision to major in engineering.

For Jasmine, pressure manifested itself differently and involved her high school educational experience or lack thereof. She attended a high school that underperformed for several consecutive years and upon graduating the school was turned over to the government. Being a student in an underperforming school placed pressure on Jasmine

because the school curriculum was always changing. According to Jasmine: “They [the School Department] kept changing different things [in the school curriculum], promising that we’ll meet standardized test scores.” However, the school never reached that goal and the students suffered with a sub-par education, as evident by the lack of AP classes.

This high school experience caused added college pressure for Jasmine due to her lack of academic preparedness. Susan, a senior studying bio-medical engineering at Lower College, experienced pressure from her community. In her neighborhood, it was not safe to inform neighborhood peers of academic prowess. Susan described it this way:

> I remember in middle school it was a negative thing to be smart so you are… your grades was very low-key. A lot of people on my block would have thought I was some type of air-head. The way I'm bubbly and happy but they would never guess the grades I would have had. Not because of the way I present myself, just the way my personality is. I adjust to my surroundings very well. It was just one of those situations that you didn't want to rub it ... Like, "Oh how did you do on this test?" You kept your grades to yourself. "I did okay." "Oh, you did okay? Good" You don't want to like [say], "Yeah, I got a hundred," because then they'll be mad at you like, "Why you trying to act White?" If you speak properly things stand out and such. Even if you got involved in activities they'll be like, "Oh you're really smart… why are you doing dancing?" Why are you doing those extra-curricular

> [activities]? Some people support it, of course parents want you around but at the same time, some students were jealous of that.

The pressures felt by these three women were different, but all could have been a deterrent to their curiosity with STEM. However, the women persevered because their interests in STEM were stronger than the pressures.

Mother, Father and Community Influences. Most of the women in the study obtained values from their parents and talked about their parents' influence on them and the decisions they made due to the influence. Through this dialog it appeared that parent / child relationships were supportive in nature. All of the women expressed having full support of their parents and knowing that their parents wanted them to attend college. Some parents were more specific about educational focus and encouraged their daughters to pursue STEM or more specifically engineering degrees. Mary contributed her interest in STEM education to her father when she recalled:

> I just really liked computers. My dad had a computer so he'd let us play with Microsoft Word and all that. He really liked computers so I guess it just brushed off on us, like, computers are cool. Now I can make it do things I want it to do. This is great. That's how it happened.

Mary's father supported her curiosity by introducing her to computers. Susan also had support from her father. Susan commented:

> He [my father] supported us, he just wanted us to learn and get good grades. That's the best way to put it. I wouldn't say that he was pushing us in one direction or the other. He was making sure we were on top of our stuff. As far as career goals, he wanted to make sure that we got involved in something that had a career path that he knew for certain we would be able to take care of ourselves afterwards.

Aisha also suggested that her father sparked her interest in science, but her interest was heightened through welding and mechanic work. Aisha described her experiences in this manner:

> We [my father and I] used to do a lot of projects together. He's a welder and a mechanic and he worked on the wharf where my family's from and he's had a lot of jobs like that. I think he just wanted to pass it on to someone and I guess I caught the bug.

Ruby attributes her interest of engineering to her mother; however, she did not know what engineering was when her mother suggested it. Jordan also intimated that her mother was influential on her decision to study engineering as she expressed her situation. "My mother is a chemist. She got her master's degree in chemistry, so she always pushed us to do science and math, of course, because she liked it."

Lola concurred and emphasized the influence of her mother in conjunction with her community and this narrative allows Lola's emotion to be heard because it is rich in

its detail and specific to her mother's actions and the involvement of her community. To date, her community is still connected to Lola, supporting her. She filled up with pride and appreciation as she spoke her truth. Lola remarked:

> My community paid for me to go to an Engineering conference in [Western College], so I went to this [Leadership Conference] and my community paid for it. I told my mom, and she was like, "How much does it cost? I'm broke. I'm low income, first gen." My mom is like, "You're not going." I cried and then she felt bad, so she did a fund raiser in the YMCA because I was this captain, I'm a swimmer, so I was in the swim team of the YMCA… then somebody from the [city's newspaper] promoted it so the people in my neighborhood, people throughout [the city] were sending donations to my mother for me to go see this conference because I was a black girl from [my neighborhood]. I was doing well and I was interested in engineering. No one does that. They gave me money, they paid for my laptop that I still have today. They paid for all the suits that I had, they paid for my flight to go [across the country] so I can go see this engineering conference. They did an auction for me, and that raised money. These are all black-owned businesses. My teachers really supported me in high school. Even some of them donated, because I was in the newspaper. I was in the articles. It was out there and they were just so proud that this young, Black lady girl...

The actions taken by Lola's mother and community enabled her to fulfill her goal to attend the engineering conference and ultimately enroll and persist in an engineering program. In contrast to Lola, Heather suggested that she developed her interest in engineering from her family's educational backgrounds. Her parents are both engineers, one set of grandparents were doctors and the other set of grandparents consisted of an engineer and an educator. Saran attributed her interest in math primarily to her mother and shared the following:

> I think I gravitated toward it [engineering] because of my mom. Growing up, math was always something I always could get help with because she'd help me in something. I just felt this strong sense of the more schooling I did I guess, the more comfortable I felt and also my math teacher in my last two years at high school was really good and he did push me but initially it was probably because of my mom, I was really interested in Math.

Saran's interest in math was sparked by her mother and ignited by her teacher. Ultimately she excelled in math because she was supported and enjoyed working on it. Lisa also suggested that her parents were influential in making school a priority. Lisa commented:

> I think my parents definitely influenced me and my sisters to make school a number one priority, and so our focus always directed back towards school. There's also the positive feedback of doing well, I think that could count. I was interested in more chemistry from like seventh grade, I would say, and then also

> my dad is a pharmacist. He would always be more interested in talking about chemistry topics, and he'd always pose these questions, like questions that he doesn't know the answer to either, or just like what do we think?

All of the women described their parents' involvement and positive influence in their decisions to participate in STEM related activities and focus on engineering as their college major. More specifically, two of the women had parents who are engineers and their influence was significant due to their first hand experiences. Lola's, experience exemplified her mother's support and the true definition of community. Together these narratives suggest that parental interaction and involvement is an influential factor in a student's educational direction and is not always dictated by socio-economic status. The data suggests that teachers were also influential in introducing and cultivating interest in science and math.

In summary, some of the women interviewed did not know what engineering was before entering college. The women just knew they enjoyed math and science courses and received positive support and feedback from either teachers and/or family members because of their aptitude and interest. This support helped to propel them further along their STEM education trajectory (Andrade, 2007, Carlone & Johnson, 2007; Ellington, 2006; Russell & Atwater (2005), Sosnowski, 2002; Valenzuela, 2006). Continuing on the trajectory to college, it was apparent these African American women in my study also performed at high enough levels to be accepted into various selective engineering

programs and have persisted. Most of them participated in STEM programs prior to college, advanced science course and/or advanced math courses in high school. These programs and advanced courses prepared the women for a college engineering curriculum and provided them with confidence and academic skills to succeed in engineering (Russell & Atwater (2005; Ellington, 2006). No matter how exposure was obtained, early exposure to math and science propelled the women into their present engineering majors.

Motivation

Motivation was another theme emerging from the study data. The African American women in my study are motivated. Their motivations developed from internal dreams and goals as well as external sources that force them to act. These women had goals of medical school, graduate school, engineering careers as well as leading entrepreneurial ventures. Some of the women also wanted to make their family and communities proud. The method by which these women reached these goals focused on how they view their external performance, mastery of the subject matter and/or their avoidance of the subject matter. Their motivations could be described as intrinsic motivation, extrinsic motivation.

Intrinsic Motivation. Heather was intrinsically motivated. She stated she was always interested in math and science and that she enjoyed problem solving and applying the scientific knowledge. She said “it just clicked for me." Additionally, she set a goal to become a doctor and this goal motivated her to succeed. Ruby’s motivation was also intrinsic. She stated, “Okay, no matter what the obstacles are, I’m going to get this [engineering degree] done because I want it for myself." Jasmine had a similar belief and commented that she was ready to be successful in her engineering program. She realized that she had the ability to accomplish many things and this motivated her intrinsically. Jasmine commented:

> What motivates me to get there is knowing how far people can go if only they have the mindset for it because, especially when we're down we get so caught up thinking, "I can't possibly do this for XYZ reason," but then I'll think, for example, my grandmother couldn't read, and my mother has a bachelor's degree. That's a pretty big difference, and it's more of a matter of are you willing to put in the footwork. When I realized that I'm like, "I can do so many things. It's just a matter of whether or not it aligns with my passion, and whether or not I'm willing to put in the work for it, so I'm like, "Oh." It's almost like a challenge, I think, actually, yeah. That's a good way to summarize it. It feels like a challenge. It's like, okay, it's just a mind game now.

Jasmine was motivated by her family history and knowing others before her had challenges they overcame, thus she believed she could overcome hers as well. Serena, a senior studying Chemical Engineering, had a strong intrinsic motivation and stated the following:

> I always find myself wanting to better myself and this motivates me. There is so much more than just being a work bug and there is so much more I can do if I could do my own research so that I could impact the environment and community.

Serna also talked about bettering herself. She commented: “In college I feel like I was more self-motivated than anything else. I would find myself doing things not for what I would gain externally but how I feel at the end of the day, I'm more internally motivated.” Simone’s intrinsic motivations were focused. She was internally motivated in order to reach her goal of graduate school. She planned on performing well to enter graduate school. She stated: “Right now, my focus is doing well so I can get into a good grad school. Then after that, I'll focus on trying to get into the career that I want.” While Simone’s motivation appeared to be more long term, Susan’s intrinsic motivation stemmed from her interest in completing her engineering degree. Susan remarked:

> I wanted to make sure that I succeed, like I finished my degree. That was my main goal. I am going to graduate with an engineering degree that I don't give up. I don't quite. I will make sure it happens. That was one of my goals. I wanted to make sure that besides knowing things, on paper, I understood things. A grade is

> like, "Yeah. I could do this." On a test it's like, "All right." I wanted to make sure I understood things. Whether it's reflected in my grades or not, is another question but I wanted to make sure that I understood everything that I was learning so I could apply it whenever needed and not just have "temporary knowledge" is what I'll call it.

Susan focused on the here and now and wanted to understand information and not just receive good grades. In review, nine of the sixteen women expressed their dominate motivation to be intrinsic. This motivation strategy was powerful in that these women set goals for themselves and their intrinsic motivation was a tool used to achieve these goals and receive inherent satisfaction.

Extrinsic Motivation. Some of the other women interviewed expressed their dominate motivation to be extrinsic, sometimes causing pressure. Susan was extrinsically motivated when told that her success in engineering was bigger than she is. This role presented pressure for her to perform well because everyone was watching and countering on her success. Susan commented:

> Some people were like you're one of the few. Even some Black faculty or staff, they'll make sure I'm on task. If I was just fooling around they're like, "Don't you have homework or something?" I'm like, "Yeah." And they're like, "Go, bye!" They were like, "This is not about you!" And I was like, "Okay, fine."

Susan was saddled with the responsibility of performing well because she was one of few Black students in engineering. Lola put a similar pressure on herself. She was raised by her mother and grandmother and was extremely oriented by family and community. She believed it was important to give back to the community, particularly when her community supported her as it did with her. Because of this relationship, Lola is motivated extrinsically by her community and family. She explained:

> What motivates me? I have a whole bunch of kids my age who were looking up to me, because they're like, "You're doing this and ..." I came from low income, first gen [neighborhood]. If I could do it, I could show them that they can do it. I have so many people looking up to me, so that's like the thing, just to show them that they can make it. They can make it out or they can do something. I'm really pro-choice, and I realize that the issue is that people don't know that they have a choice, so to just show people that they have a choice and that this is what they can do. I can't let my neighborhood down because they worked hard and they supported me, so that's one of my motivations.
>
> My mom is already proud, so I would say to my mom that ... she's happy with whatever I do. It's more of my neighborhood; then also, for my grandmother. She just passed last week, Monday, and I just came back from [my home town]from the funeral, so I've got to make sure I continue that, make her proud, because she

> ... I'm her only grandchild. My mom was the only child, so it was just us three women so to continue that and make her proud.

Unlike Lola, Aisha experienced extrinsic motivation and pressure from her family. Aisha has a family that motivates her, because mediocrity or failure is not an option. She described them in this manner: “I don’t necessarily have the type of family who’s very pleased with mediocre things; it’s not n necessarily accepted." Nicole is also motivated by her parents who require her to perform well in school to secure a good GPA. Nicole went on to say the following:

> My parents have always just expected me to do well. In high school, they didn't have to worry about me as much, but I know that here, they expect me to do well. They're paying for me to come here. That if I don't do well, they're not going to keep paying for me to come here. I guess, just for myself, I know that your GPA isn't as important once you graduate, but it's important to me. I just want to graduate knowing that I have a good GPA, and that I worked as hard as I could in all of my classes. I guess understanding the information is important, since all of our classes tend to build off each other, but I think that good grades come with understanding the information.

Brandy’s motivation was different from that of the others because she was motivated to just finish her degree to get this experience behind her. Brandy’s extrinsic motivation was fueled by her desire to complete her degree such that funds spent on the

degree would not have been a waste. She was no longer aspiring to become an engineer and she was completing her degree because she was too far along to switch out of engineering or quit. She also did not want to let her family down because she was the first person in her family to major in engineering. Brandy shared:

> Sallie Mae is the biggest motivator of them all, just the fact that I'm in debt and I need to get an advanced degree. It's like this sucks but you can't stop here. I don't want this to all be for nothing. Right now it feels like it's for nothing. However at that time I thought oh no, I cannot be in that number of kids who drop out. It's not worth it to go through all these trouble and then be scraping along [financially] forever.

Saran's motivation was different than Brandy's, in that her motivation did not affect her as Brandy's motivation affected her. Saran was motivated by her support network from the [EXCEL] Program she participated in. Saran suggested:

> I think one thing that really helped me was I was part of another program called the [EXCEL Program] and they take in Engineering students, mostly disadvantaged, of color, or that come from backgrounds that might put them at a disadvantage and they, we did summer classes and I think that was a really good support network I had to talk to other kids in the group but also the mentor I had. I think whenever I felt like I needed to motivate myself I would definitely go to them or someone to help me get back into the rhythm of school.

Serena shared the fact that her motivation was extrinsic originating from external sources as well as intrinsically from within. She explained:

> In college I feel like I was more self-motivated than anything else. I would find myself doing things not for what I would gain externally but for how I feel at the end of the day, I'm more internally motivated.

Serena was also motivated by her faculty. She continued on to say:

> I actually liked professors [who] are strict; they force us to actually get the work done and get them done well. I think it's kind of a challenge for me in a sense. He was one of the very strict professors and I liked him for that. He was kind of motivation for me.

All of the women in the study were motivated to complete their degrees and already concluded they were not going to allow any obstacle to deter them from their goals. All sixteen women were highly motivated and this motivation represented an element associated with high levels of success in STEM majors (Maton, Hrabowski III & Schmitt, 2000).

Academic Achievement Goals

More specifically, and through the lens of academic success, these African American women persisted to degree completion and in doing so, were utilizing motivational constructs of achievement goal theory using performance goal strategies, mastery goal strategies, avoidance strategies or a combination thereof. All of the women worked towards reaching their academic achievement goals in their undergraduate endeavors and beyond. Most of the women commented on the importance of completing their degree. A sub-section of the women stressed the importance of finishing with strong, if not perfect GPAs, allowing them to accomplish other goals.

Academic Performance. Of the narratives below, women focused on two academic goals: to finish their degree and graduate, and to graduate with a certain GPA, while focused on their academic performance. Skyler stated that she wanted: "To finish... I really wanted to be in alternative energy, and I still do." Nicole realized that engineering was challenging and wanted to finish as well as graduate with a certain GPA. Nicole commented:

> When I came to this school, I was the top of my class. I was a straight A student. I came here thinking I would finish with a 3.5, and get my bachelors, and go to grad school. Now I just want to graduate with my bachelors, and do well. I want

> to finish with a 3.0. I guess my expectations for that have changed. I realized it was hard, and that a 3.5 isn't. Most people aren't going to end with that.

Nicole realized an engineering major is more rigorous than she anticipated but she was interested in improve her GPA and graduating with her engineering degree. Saran also wanted to focus on her grades and determine the direction in which to focus on in college. Saran stated:

> Of course I wanted to get good grades but I think my goals were mostly to really figure out what direction in engineering I wanted to go in and just what I liked, mostly. I can't think of if I had any specific goals. I can't think of any right now besides do well.

Besides performing well, Saran did not have any specific academic goals. However, as she continued to persist in the program she explored subjects of interest. Simone was more specific and was focused on the bio-medical field. To be successful, she needs to increase her 3.15 GPA to qualify her for a bio-medical graduate program. She did not have a specific GPA in mind but knew she wanted to improve her present GPA. Simone commented:

> Honestly, I would like to get my GPA up. I decided that I wanted to minor in bio-medical, which is a recent discovery from my internship. Then I began looking into grad schools with that and they have very specific requirements. I think my goal is to just be able to master those and ensure that I actually can get into a good

> school because right now, I'm thinking I want to go to [a prestigious institution] for grad school. They have really high expectations. My goal right now is just to meet those. I need to get the GPA up, take all the necessary classes. I also want to do another internship, but I want to do it in the bio-medical field this time instead of just engineering.

Simone concentrated on the opportunity to enroll in graduate school and this encouraged her to improve her GPA. Jordan's motivation was laser focused. She had been consistent with her 4.0 GPA and was working toward graduating with her 4.0 GPA intact. Jordan remarked:

> When I graduated high school I had a 4.0, I was valedictorian but it wasn't …It's an accomplishment, kind of, but high school wasn't really super challenging. I came to college and I wanted to prove that I could also do well even in an actual challenging environment. That was my goal. I do have 4.0 now, actually, but it was definitely hard for the first couple years because I was trying to catch up.

Kelsey's goal was to graduate and make the Dean's list. She reflected on the situation in this manner:

> Graduate for one (laughter) from Middle College. I just want to push myself and just see how far I can go. Because I know I can get there. It's just about finding a way to get there. I was very close to that this year but I didn't make it

> unfortunately. I was like one grade below. But that's what I want. I want to make Dean's List before I graduate. I would love to try to get straight A's.

These women were highly motivated and set performance achievement goals for themselves enabling them to focus on the goal of graduating from their respective engineering programs, and take their next step into academic or workforce activities.

Knowledge Attainment. Other women in the study used mastery goals strategies to work toward their end goal of graduation. Serena was very interested in obtaining as much knowledge as possible and planned on accomplishing this when she attends graduate school. She wanted to master the information and explained it in this manner. Serena stated:

> But then at the end of the day I see the significance of getting further, better, like more knowledge and I always feel like there's so much more for me to learn. I haven't learned everything yet, and under grad was great but I feel like I need more to run with. Hopefully I get that from my graduate degree.

Serena planned to learn additional information related to her field of study as she participates in her graduate studies. Lisa's goal, similar to Serena's, was to secure a solid understanding of the information she learned because she wanted to become the expert. Lisa shared the following:

> I definitely want to just have a very solid understanding, a foundation, of what I'm learning. I think it's more important to me to fully understand the topics that I'm learning, and sometimes there are ways that you can spit out really good grades through strategy and it might not reflect your actual knowledge or that you're able to retain that for years to come. My goal is more like feeling confident that I know the material and I can call myself an expert.

Lisa wanted to be more confident about the information and be an expert in her field of study. Like Lisa, Jasmine wanted to be an expert in whatever field she studied. Jasmine reflected on it in this manner:

> I really hope that by the time I'm done with my studies, and I hope to go beyond Bachelor's, that I feel as if I can say, "I'm an expert in whatever specific field of study I am in. I want to feel as if I'm very, very confident in the material that I know.

Susan, like Jasmine was dedicated and motivated to complete her engineering degree and master the information. Susan commented:

> I want to make sure that I succeed, like I finish my degree. That is my main goal. I am going to graduate with an engineering degree that I don't give up. I don't quite. I will make sure it happens. That was one of my goals. I wanted to make sure that besides knowing thing, on paper, I understand things. Whether it's reflected in my grades or not, is another question but I want to make sure that I

> understand everything that I am learning so I can apply it whenever needed and not just have, "temporary knowledge" is what I'll call it. I wanted to be a little more well-rounded. I noticed that a lot of engineers in general, they don't have good communication skills or are not able to interact with people well. I wanted to make sure I have leadership skills, that I am involved in the community. I'm always big on giving back and doing different things so besides my academics goals, I wanted to make sure that I have a well-rounded experience.

Five of the women interviewed were driven to master engineering content. Ruby wanted to understand the information she learned, Lisa and Jasmine wanted to leave with a solid understanding of information and become experts and Serena sought to be secure in the knowledge enabling her to conduct research and create additional knowledge. These women were highly motivated and set mastery achievement goals for themselves, enabling them to focus on understanding and mastering the engineering information; and, this motivation propelled them towards graduation in their respective engineering programs. Eleven of the women focused on performing well and securing exceptional grades. Skyler just wanted to perform well and finish, whereas, Lola, Heather, Susan and Simone desired to perform well to gain entrance into graduate school and Jordan needed to prove that she can secure a 4.0 GPA for the duration of her undergraduate degree, Nicole wanted to finish her degree with at least a 3.0 GPA, Kelsey wanted to make Dean’s list, and Mary and Sara wanted to perform well and produce good grades. These

narratives demonstrate the commitment these women had to their degree completion and goals they set for themselves.

Work Avoidance. The work avoidance strategy had a negative effect on students and Brandy, a junior studying chemical engineering at Upper College, was the one student in this study who was negatively affected. The climate was so chilly and unwelcoming that she sometimes avoided the situation, whether it was to obtain assistance from a professor and/or work with a group of White students on a class project. While some women recognized and/or experienced a chilly and unwelcoming climate, Brandy was the only woman who was deterred by it. Brandy stated:

> I didn't really talk to people. I don't really have friends in my major. I don't do any work with anyone. I don't collaborate with anyone. One professor this semester has really reached out. He really has. I've told him it's not just you, don't take it personally. I'm just a mess. He's like OK. Then he'll email me and be, "Anytime you need to answer a question. I'm like, a little intimidated by my subject professors. I don't like talking to professors one-on-one. It's scary to me so I go to [teacher assistant] TA office hours and he'd [faculty member] be walking by and pop into the room. "Hey." And come and sit next to me. Some of them do try and some of them are, "You're wasting my time." They would never say you're wasting my time. A complete opposite of him is a professor who'd say,

> “Come see me.” Then you'll ask him a question and he’ll disrespect you [by saying]. “You should know the answer to that.” You're [saying to yourself], “OK. Never talking to you again.”

Brandy’s situation was a result of the systemic racism students of color face in higher education institutions, causing them to withdraw from their academic program. Fortunately, Brandy plans on completing her chemical engineering degree, but does not want to follow a career in engineering.

The motivations defined by self-determination theory (intrinsic or extrinsic) and by achievement goal theory (performance, mastery or work avoidance), were integral elements for these women as they persist to degree completion. These motivations, except for work avoidance, kept the women engaged in activities of their respective engineering programs. As seen through Brandy’s experiences, systemic racism is a significant contributing factor in work avoidance and will be further discussed in Chapter 6. Along with their motivations and goals the women utilized learning strategies that helped them persist in their undergraduate engineering programs.

Learning Styles

All of the women described themselves to be visual learners. Most of them expressed the manner in which they reinforced their visual learning with some process of doing. This doing activity included homework, talking through subject matter with peers, and/or taking advantage of time with professors or TA's. This section examines learning styles used by some of the women in the study. Mary's learning style consisted of a combination of steps. Mary commented:

> I learn through a combination of reading, watching and then doing. I learn the best when I am able to watch someone do something and then get to try doing it myself or some variation of it to suit my own purposes.

Mary was a visual learner and Jasmine was a learner who needs to explain and verbalize her learning and this step is important to her learning process. Jasmine suggested:

> I have found that I learn best from doing the problem very slowly and verbalizing everything. That's the important part, the conversation. I need to be able to summarize and say, "So you do this in this way because…" I need to be able to make connections to things. I didn't realize how unusual this was until my freshman year. I think it's because I didn't do much technical things in grade school. I think my more wordy/conversational learning style might come from that fact that my skills are stronger in the humanities and writing.

Jasmine needed to verbalize and internalize the material she learned. Skyler take a an approach where she studies by herself most of the time. Skyler reflected:

> [I studied] by myself mostly. Every once in a while you're in a group for a project or something or you've got a test coming up so you get together. I find I do better when I do practice problems and go over it with either a peer or a teacher so they can correct it for me. Sometimes I didn't, that's the best way for me to study, bucket loads of practice problems forever and ever and ever. Correct them. Go over those mistakes.

All of the women had their own specific learning styles and study habit, however, all of them committed a great deal of time and effort ensuring that they understood course material. These efforts took on the form of purposeful work and these women determined the method that suited them best.

CHAPTER 5

FINDINGS

INSTITUTIONAL AND ENGINEERING COLLEGE EXPERIENCES

This chapter focuses on findings describing institutional and engineering college environments experienced by African American women interviewed. In this environment the women came in contact with faculty members and peers, they experienced collaborative and competitive atmospheres and from these experiences their sense of belonging, science identities and career goals were affected in positive and/or negative manners.

Institutional Support and Institutional Barriers

The campus environment is a fundamental ingredient in a student's sense of belonging and plays a significant role in providing support for students to thrive academically; however, this environment can also produce barriers that obstruct goal-oriented behavior (Murray, 1938; Weiner, 1972). Most of women interviewed took advantage of support offered by their institution, engineering college or academic peer group. These academic peer groups were created in various ways. In some instances,

faculty assigned teams for group work, but in many instances students selected or were selected by peers.

Simone did not realize the amount of support her institution provided until she began comparing the support she had access to with her peers at other engineering schools. Simone concluded the following:

> Well, from talking to people who don't go here, there is actually a lot more helpful than I would think. Like if I was just here and I had no outside opinions about their schools, I wouldn't think that it wasn't that great, but after talking to other people, I'm like, "Oh wait, I'm lucky." They actually help us. They actually support us. If we go there, we go to the engineering office, we say we need to find a tutor in this class, they'll let us know. If we say, "Oh, we're not really understanding this professor," they'll help us out to switch a class. "We need help with this internship," they'll send us to the career center for a mock interview, things like that. The resources are definitely available here. They will help you which apparently at a lot of other schools, that doesn't exist, at least on the level that it is here.

Simone did not realize the amount of support she had access to until she heard her peers from other institutions talk about support or lack thereof they received. Jordan's interaction with the institution was largely through a dean who was very supportive. Jordan stated:

> I haven't had that much interaction with the Civil Engineering department, like the general college of engineering; we have [the Dean] there so that's really helpful. He pretty much helps all of us. He can advocate on our behalf as an organization [NSBE] and as student as well.

Jordan utilized her relationship with the Dean, unlike Lisa, who sought assistance focused on future career opportunities. Lisa stated that her program gave her the opportunity to explore topics and this exploration allowed her to figure out what career she wanted to focus on. Lisa remarked:

> I have a chance to really figure out if I would like my potential career, through internships, and the program office here is better than others in terms of being able to work while in school instead of waiting until after I graduate to figure out I might not like my career.

Rather than through a specific person, Lisa's engineering program allowed her to explore different career paths and this supported her. Ruby and Lola believed there to be many useful resources on their respective campuses. Lola expressed the fact that there were many resources on campus, of which she took advantage. Lola stated:

> There [are] a lot of resources on campus. I could definitely attest to that. It's not a competitive environment. It's more like a helpful ... Was another reason why I came, because I wanted to go to [a southern technical institution] but even the Black people there told me, "It's people, they try to wean you out." Whereas here,

> if you want help, you can ask anybody for help and they'll help you…which is really awesome. The Math department has a Math Tutoring Center. You can go there for help. I usually go there. Physics has a Physics Help Desk. You can go there. Along with TAs and office hours and different positions on campus, there's a faculty advisor, there's a community advisor; these are all the resources there to help you. As far as education, that's fine. Academic help, I get a lot of help and it's available.

Lola took advantage of the support provided and made it work to her advantage. While acknowledging the support on her campus, Ruby also revealed that she did not proactively seek out support. Ruby stated:

> Individual people who had positions within the administration I see act, like my dean and my advisor. They were there. I'm definitely not a person who seeks help when I need it, so they were very proactive like "Come see me, we need to talk. Let's do this, let's figure out an action plan." They helped a lot.

Even though she was not proactive, Ruby utilized the assistance when it was offered. Susan also believed there to be several support options on her campus and she understood students had to be proactive in order to obtain support. Susan suggested:

> There were things available if you search first. They did have support in the under-grad office. There's the career develop education resource center. The education resource center so if you ever needed help, there was tutoring options

> either through the college of engineering or generally through the university if you needed it. Office Hours... Professors are very helpful if you need it.

Susan was proactive in seeking out support and recognized students needed to take initiative. Simone was more specific with the avenues she used for support. Her institutional support came by way of her academic advisors. Simone stated: “Definitely the two Assistant Deans here for the College of Engineering. Those two, by far, they help with everything. One of them is also our academic adviser for NSBE."

Jasmine was able to develop strong relationships with some administrators. She stressed the belief that engineering administrators at her institution, specifically an advisor and dean were very supportive. Jasmine said:

> I consider the academic advisor, the assistant dean, and advisors who aren't even my advisors to actually be incredibly supportive. I really appreciate how they're able to tell whether or not a student is struggling but still has the potential and still has the passion.

However, Jasmine did have a negative experience with the administration that left her frustrated. Jasmine recalled the experiences in this manner:

> The advisor reached out to a dean when she didn’t agree with something I wanted to do. Now, this dean has nothing to do with me in terms of advising. I choose to see him. I choose to confide in him because I respect and highly value his opinion. But this advisor reached out to him so that he could lecture me. I was

> very suspicious of that because: How does she know that I go to him for everything? And are you making assumptions that he has some sort of control over me because I'm an engineering student of color? (One of the things this dean does is work with students of color in the college of engineering). At the time, I was incredibly frustrated because I wasn't being spoken to directly, and she was making assumptions based on how I looked. I have not worked with her since and actively try to avoid her.

Interaction with administrators in their respective institutions and programs proved to be a positive ingredient in the women's academic success. There were myriad support mechanisms available and the women determined they were able to take advantage of as much of it as needed, whether it was receiving advice from a dean, career counseling, tutoring or from a teacher's assistant. Moreover, the women who built relationships with the college dean like Jasmine, Jordan and Ruby as well as other administrators were able to reap benefits of opportunity and information. Additionally, the recurring theme of proactively reaching out to potential support was echoed by Susan. She continued by saying that there were a great many resources but students have to seek them out.

Sense of Belonging

Counterspaces. Most of the women interviewed conveyed varying sense of belonging, resulting in the conclusion that levels of social and academic integration exist. An environment where the women felt a strong sense of belonging was their involvement in the National Society of Black Engineers (NSBE) activities. This organization is an example of a counterspace. This organization or space does not reside in the limits of classroom space and enables African American students to discuss challenges and concerns while bonding with other African American students who share cultural backgrounds that are similar. This counterspace also allowed the women to affirm the ethnic and/or racial aspects of their identity (Carter, 2007; Solórzano & Villalpando, 1998). NSBE is an external national organization with a mission "to increase the number of culturally responsible Black engineers who excel academically, succeed professionally and positively impact the community" (NSBE Website, 2016). Each NSBE college chapter is student-led and is usually supported by a faculty or administrative advisor.

The majority of the women interviewed discussed their active participation in NSBE. Along with participation, others held leadership positions as well. Jasmine, Jordan, Brandy and Kelly held leadership positions and the remaining NSBE members were active in community service activities and tutoring sessions both giving and receiving. The presence of NSBE on each of these campuses was important to these

women because it served as a place to see familiar faces and where individuals were able to ask for, receive and provide support.

A Community Feel. Most of the women participated in the counterspace NSBE where they experienced a positive sense of belonging and cultivated a circle of friends who supported them academically and socially. However, some of them did not feel as though they belonged to the larger engineering community. Brandy, in particular, shared her lack of a sense of belonging in a setting that was designed to support women in engineering, specifically the Society of Women Engineers, a national student organization created to provide a place that gives women engineers a voice. In her freshman year, Brandy tried to join the Society of Women Engineers and decided not to join because she felt as though she did not belong. Brandy explained it this way:

> As I look around, you're the only black girl. I even made a comment about that when I was there. They had a welcome week for female engineers. The whole week it was maybe 120 girls and five of us were black. The five of us, were just all five. We weren't talking to each other at that point. We were all fish out of water.

Brandy did not feel as though she was part of the community when she attended a SWE event causing her not to join. Susan dealt with her lack of community differently.

She felt like she dealt with her White peers enough and wanted some separation. Susan commented:

> Honestly, I felt like there was a certain degree of separation until my senior year. I wasn't really too involved in the engineering community as a whole. I was involved in National Society of Black Engineers (NSBE) and the Black community. As for the engineering community, like I said, there was…. like the smell. There were things that made me just not want to be a part of it but at the same time any time I would get close to certain people they would just do something or say some stupidity, like something really stupid [that was racially derogatory and stereotypical]. I don't have time for this, this is my off time. I'll deal with the stupidity in the classroom but I don't want to deal with it during my social time. It's just one of those, I see you enough in the classroom, let me just have my nice separation sometimes.

Susan had a hard time working with her peers and did not work with them in the manner she wanted. She tried building relationships with other students but they often did not last. In her academic environment, Skyler was the only African American woman and she felt as though she was an outsider even when she participated in study groups and student activities. Moreover, she did not think her peers were ethical and she understood they would do whatever it took to obtain good grades, including cheating. Skyler was not

willing to engage in this behavior and this decision separated her from her peers in her academic community. Skyler explained it in this manner:

> The engineering community, not really [did not feel a part of it]. Like I said, the engineers kind of were more…they just did their own thing. Obviously there are exceptions, some of them were cool. But, in general they are not as social and stuff. I don't feel like I particularly, I don't feel like I'm with them or something.

Skyler did not feel as though she was part of the engineering community because she was the only African American woman and she did not feel connected to her peers socially or ethically. Jordan connection to the engineering community was a little better. She felt that her connections to the engineering community to be mediocre. However, she had a sense of belonging when she participates in NSBE. Jordan stated:

> I guess I feel like a so-so bond [with the engineering community]. I'm not really involved in the civil engineering group. A lot of our professors are really, they push the civil group. It's like that in the civil industry too. If you don't have the American Society of Civil Engineers on your resume, they'll be like, "Why?" But I don't really participate with them just because I decided to spend more time on NSBE. Then I realized also, after getting my degree, I didn't really want to be a civil engineer. I don't really like the career options available.

Jordan decided to dedicate more time to NSBE and no other engineering organizations and as she and others described, NSBE was a comfortable and welcoming

place for these women to participate in. Lisa felt connected to the chemical engineering community but did not feel connected to the rest of the engineering disciplines and did not think there was a method to bring them all together. Lisa expressed the following:

> I've never really thought ... There are always subsections of the engineering community [due to the different engineering majors]. I definitely don't feel like a part of the mechanical, electrical, civil, or industrial computer engineers. In chemical I feel like a part of it. I feel like people know who I am and I know who people are. Also, the club I'm in [NSBE] is actually a mixture of both, but it's ... Within that, I feel pretty ingrained, and also within the college of engineering itself ... The Assistant Dean knows me, obviously, and I have helped them with various volunteering, projects, or whatever, so I feel like I'm known to one or two people within the college of engineering, the administration, so in that way I feel pretty connected; sometimes, but not really.

Lisa felt very connected to the chemical engineering college because that was where she spent a significant amount of her time. Jasmine felt included in the engineering community due to her involvement in NSBE. Jasmine expressed her feeling this way:

> I feel very much involved because of the student organization [NSBE] that I'm in. Before being on the [leadership Team] I was always questioning whether or not I fit in with the other engineers, because I felt incredibly underqualified, but I

> definitely feel, I feel involved more so than other students because I'm constantly having to work with, every time we want to make an event we have to get a signature from this advisor, or do this thing, and then we're going to rent out a huge room in [the Engineering Center] and have all these companies come over. It's a little bit of a boost to the ego because I feel like the engineer organization; we're kind of like the face in a way. That was a nice source of pride in the very beginning, so I do feel very much involved. People come out. People come out to the meetings. People come out to the events that you hold, and I think that says something. Obviously there must be some positive word going out there, so that means as a collective you're doing well, so yes, I do feel involved.

Jasmine felt a great deal of community as an active member of NSBE. The organization supported her and allowed her to support others. Serena acknowledged that her involvement in the engineering community had increased because she made a concerted effort to be more involved. Serena stated:

> I think my part in the engineering community has increased over the years. I went for the SWE conference, the NSBE conference, I feel like going to conferences is being part. I was also the Lab Manager for the Computer Lab, I kind of knew what was going on inside and stuff, like the events going on and I partook in some things, like just being involved. I feel like I've done more than I even expected to

> at the end of the day, and I try not to let color or whatever affects my desire to partake things. I think my involvement has improved over the years.

Even with different levels of a sense of belonging, Jordan, Lisa, Jasmine and Serena all had a positive relationship with the NSBE organization. However, the NSBE involvement did not hide the feeling of being an outsider in the classroom, as described by Ruby. Ruby felt like an outsider in her classes due to the nature of the department. Ruby stated:

> I felt like an outsider a lot of times in the classes. I didn't feel like I belong. I think it's a nature of this department specifically. This one [department] has the most guys. Since there's a lot of stuff that's coding it's very ... You do it yourself, and a lot of individual stuff. If you didn't reach out to people, it wasn't like they were going to reach out to you. Maybe in mechanical and chemical it's different, but electrical, it's ... I think it's just the nature of the work.

Ruby experienced sexism in her learning environment that was populated with a substantial amount of White men, causing her to feel like an outsider. Simone, in contrast to Ruby believed she was very involved in the engineering community and commented:

> I think I'm pretty involved. I like to go to a number of the clubs. It's not necessarily that I'll go on a regular basis, but I'll go to the mechanical engineering club or our IEEE, I go there sometimes, the Bio-medical Engineering Society. I like to be involved and to get connections because I've learned that is very

> important. I also like to talk to the grad students because they always like to help. These people [the other undergraduate students] don't really talk to them, I guess. The undergraduates don't really pay them any attention. I make it a point to talk to the grad students especially within engineering because they have all kind of connections and I don't know. For me, it's really important to make sure that I get other people's points of view on where I want to go, just to see if they have any suggestions or maybe "Oh, this institution is better. You should talk to this professor. They might be able to help," things like that. I'd say I'm definitely involved. The faculty, if I had a class with them, they know me.

Ruby took advantage of all opportunities to build relationships. She talked with graduate students as well as members of technical organization she was interested in. Aisha circumstances were different and she had regrets due to her lack of involvement in the engineering community. Aisha expressed it in this manner:

> As a whole, [I do] not really [feel part of the engineering community]. In this school, honestly because I had two medical leaves of absence, one of my largest regrets is that I didn’t get involved more. I just wanted to catch up, if that makes sense, to graduate on time.

The women highlighted here experienced different feeling about their sense of belonging. However, only two of them, Serena and Simone felt a sense of belonging and participated in other engineering organization besides NSBE. Simone mentioned

specifically that it was important to make connections with as many individuals as possible and she accomplished this by attending several engineering activities and developing relationships with graduate students. The decision to participate in NSBE was the choice of each student and was not an engineering department requirement. As discussed by many of the women interviewed, NSBE was a sense of belonging anchor. It continued to be a significant mechanism by which the women found and provided support, confidence and friends.

Intrapersonal thoughts.

Some of the women discussed their introspection as it pertained to the manner in which they were perceived amongst their peers and faculty members and/or how they perceived themselves. This thought process affected their sense of belonging. As an example, Susan had a challenge with White students who had not ever been in contact with African American students and this forced her to learn patience. Susan reflected: “I had to learn. I learned patience very well.” Similarly, Brandy had a challenge coping in her engineering environment. Brandy stated:

> I think it’s all self-image. I'm not going to say I was overconfident in my abilities. I was confident in my abilities when I came here. Then I feel I started to get challenged and I felt alone. There were all these other things, academic challenges and it all went over. I don’t want to be here anymore. This has been a very

> emotional and horrible experience; that also made me think of one thing. My big goal that I had coming in was being a Black female engineer. I feel like, "You have to be a role model for Black girls. You have to do this for Black girls." Everything is for Black girls. Coming in, I really wanted to be a motivator. I really wanted to make that my thing; that I can uplift Black girls in STEM engineering. Now I'm, "Do it if you want to, at your own risk." It's unfortunate.

Brandy lost her confidence and Skyler felt similarly in that she was unable to totally release these feeling of inadequacy. Skyler stated:

> Like I had said before, because I was the only female and the only Black girl in my particular class, I always felt like me not understanding it weighed more heavily on me because I felt like my peers would think certain things because of it. Oh, she's just dumb anyway. Whether that actually is true or not, I'm not sure. It might have been in my head more so than anything, but I felt that in the back of my head, and I would try to push it away. Like, no, I tried to reject all of that like, oh it's 'cause I'm Black, mentality. But it did make me feel bad, like why don't I get the stuff or what is it so hard for me? And, yeah, it just lingered. It's like the bogey man.

Similar to Skyler and Brandy, Saran stated that her academic performance was negatively affected due to her race. Saran remarked:

> Being a student of color, I definitely had days where I felt like it affected my performance but I think it was definitely on a personal level. There would be days where I would notice or it would occur to me that I was the only person of color in a class and then I think that personally affects me for however long but other than that... I just remember a few exams I did really bad and I would walk back to my dorm and immediately the first thought was it's because I am a woman, it's because I'm Black.

Comparable to Skyler, Saran and Brandy, Jasmine stated that she was embarrassed about her performance in engineering. Jasmine commented:

> I had to retake calc[ulus] 1. I took it in high school and I still took it twice here, so something must have fed into the resilience. Otherwise, if you were to look at the patterns, most people would have switched out by now sadly. I say this with pride now, but at the time it was embarrassing.

While Jasmine was embarrassed she did not allow this feeling to deter her and she was now proud of her own accomplishments. Skyler, Brandy, Jasmine and Saran had the additional burden of opposing the stereotypical narratives that suggested they were not capable of persisting and being successful in their engineering major. Skyler likened this narrative to the “Boogie Man” because she could not touch it but she felt its negative affect and she was forever fighting against it. Saran did not name it but she also knew the feeling existed and had a negative effect on her. Saran, Brandy and Jasmine implied this

feeling in their narrative, but Skyler was able to name it as the “oh it's ‘cause I'm Black, mentality”. It was important that she was able to name it because this knowing gave her the ability to purposefully combat it.

Non Academic Activities Beyond the Classroom.

Some of the women participated in activities outside of the classroom, like NSBE and these activities provided balance and a sense of accomplishment. Susan participates in extra-curricular activities in order to give back [to her community]. Susan stated:

> What I'm doing is being a stepping stone for other girls, like an inspiration for other girls; that they can do it also. I do, I would mentor at some high school around the Boston area and then I would tell them about my experiences. I went abroad to study engineering at one point and they were like, "Oh my gosh, you did that? It's cool!" I was like, "Yeah, you can do it too." You’re telling these stories to other people so they could have belief and hope in themselves like, "This could happen to me too." Some people really don't know there's more to this.

Susan valued giving back to the community similar to Skyler; the only difference was the community types in which they served. Skyler spent her spare time giving back to the community. Skyler remarked:

> Spring break is known for going to Miami and getting plastered. Instead of doing that, we go to certain places and volunteer. One year I went, I went to [a state in central US]. We went down there to help people who were still dealing with FEMA and [hurricane relief], eight years later even, at the time it was. I also had the opportunity to help create one in [a New England state]. They wanted to help their backyard, I guess we called it. They didn't have an alternative spring break locally, so I had the opportunity to create the curriculum for it and my friend and I, we helped coordinate the whole trip. That was really cool. Yeah, and we helped raise $25,000 for them to re-do their teen center. That was also very rewarding.

This type of extra-curricular activity was very important to Skyler and it brought her great fulfillment. In a related fashion, Jordan spent a great deal of her spare time giving back to the community as well as being creative, musically. Jordan commented:

> I've just done a few different recent roles; the [Coordinator] for the [League]. The [Center] in Upper College runs this [program]. I was coordinating those tournaments. Before that, I was a tutor at a high school. Before that I was the [STEM Group] Pre-scholarship Chair. Then I've also done helping high school seniors find a college, random things, helping people to file taxes. It's just nice to do something that's not engineering. I[also] play in the orchestra.

Similar to Jordan, Simone was very active in community related endeavors as well as other outside activity like swimming. Simone stated:

> I'm also involved in the Black Student [group] here. I'm on the dance team. Well, two dance teams. I do community service. I'm an engineering ambassador, so I do the [engineering tours] and things and then do it throughout the rest of the week whenever they call me. Once I got here on campus, NSBE had a lot of community service, actions, and things that they wanted to do. We do a lot of partnerships with the elementary schools and the middle schools here, and I found that I like working with inner city kids. Helping them, making sure that they want to go to college and helping them realize that they can go to college and helping them be able to access all that community stuff they have to get here. That's also been really important to me because from where I grew up, most kids don't go to college. Coming here, I realized that was my way of giving back. I got here, so let me help someone else get here. That became really important to me. I like working with younger kids.

Providing mentorship in the community was important to Simone and this need to mentor developed from her experiences growing up, enabling her to understand the impact of giving back to inner city youths. Heather used her free time to gain support from the sorority she belonged to. Heather pledged a sorority in order to create a supportive peer community. Heather stated:

> They [her sorors] are a great support. They are more just a social support. They help you academically in everything and they reward you when you have great

academics. It is like you know more people and then [you] know more girls throughout the school which is like huge.

Most of the women interviewed participated in NSBE activities and some were more active than others. Additionally, four of the women specifically sought out extra-curricular activities that were not academically focused and provided a service to a community, whether it was to assist with disaster relief or work with inner city kids. This type of activity was rewarding and provided an opportunity for them to make a difference in someone else's life. The women who worked to help in the community were committed to this service and thought it was their responsibility to give back. Skyler, for example, created a service project in an area that was in need and Susan, made a difference for inner city kids.

Faculty Interaction

Most of the women interviewed understood the importance of faculty and worked towards building positive relationships. In all instances, the size and/or climate of their institution or program appeared not to be a significant factor in this understanding. Faculty-to-student interaction was an important ingredient to student success as described in the eleven narratives below. Now that the women are in their junior and seniors years, they have developed strategies to develop positive and productive faculty relationships. Some of them expressed the work

needed to build confidence, and avoid or work around faculty who were unapproachable. However, the women developed and effectively used methods as they built relationships with faculty.

Positive Faculty to Student Relationships.

Ruby had personal relationships with her faculty members and this enhanced her academic experience. Ruby commented: “I don't think I have any negative experiences with any faculty members or peers. Most faculty members know me, so I think that's a help; [I have] very personal relationship with everyone.”

Ruby’s relationship with her faculty enriched her academic experience. Jordan, in comparison, had to build her confidence to better manage her relationships with faculty members. During her first two years in the engineering program, she described some of faculty as intimidating, non-caring and people who questioned her academic abilities. However, as she understood their expectations as well as her own abilities, her confidence grew. Jordan explained the situation in this manner:

> A lot of times, the math professors, really, they just love math so much, they just want to teach it to people. They’re willing to spend time with you and make appointments, that sort of thing. That’s been really good. I know a lot of my friends in [NSBE], especially in the chemical engineering department [did not

> have this experience] because their professors are mean. They just feel like they're going to go and they're just going to be talked to like they're stupid. I've had that happen to me before, but at the end of the day, even if someone thinks you're stupid as long as you know you're not. You may feel like you are, especially if you're not doing well in class, you have all this evidence to show that you're not smart. Then you go to your professor and they just confirm it. It's a bad situation, but I really haven't experienced that too much. After the first couple years, I got the hang of it. The major professors who care a little less, I had already built-up my confidence [to handle them] by the time I had to deal with them, from the first couple of years professors. I just had a couple of really good professors that sat with me, worked with me and made sure that I was succeeding. That really helped. They're [faculty members] fairly supportive. Obviously, you'll have some that are more than others. You also have to try and make a good impression, especially when you're in a class with them, make sure you're showing up, paying attention and doing your homework, that sort of thing. Otherwise, they won't really want to talk to you.

Jordan built her confidence because she excelled academically, with a 4.0 GPA. She understood what faculty members expected from students, and she delivered it. However, not all of the women had positive experiences or gained such support as Jordan. Serena was focused and knew she wanted to excel academically, enabling her to

attend graduate school. With this goal in mind she did not allow anything to deter her from her focus, not even a faculty member who made racist comments towards her. Serena decided she would follow her goal and not let anyone deter her from it. Serena explained the situation in this manner:

> I had a class where apparently the teacher had been making racist comments and I didn't even know. It was actually the [White] students who complained about it at the end of the semester and they were like, "Oh yeah, you know this professor was really this," and I was like, "Oh, thank you guys, I didn't know." I didn't even ... I was really surprised the professor actually came to me and he was like, "Oh the people complained but I didn't mean to. I apologize." I was like, "Oh, no need." I didn't even realize there was an issue. I've had instances like that, just here and there. I try not to focus on the negatives, although it's not right but I feel like if I should focus on all of the crazy things going on I wouldn't get to where I need to so I just push them aside. I keep moving.

In this instance, Serena mentioned that she did not notice the racist comment and I suspect this to be the case because she decided not to give it any weight. Serena also took advantage of other faculty who were supportive and available to assist her. Serena explained in this manner:

> I think they [faculty] are very supportive especially some of the professors, they really want to make sure that the students are learning and they really want to

> make sure that we give feedback on experiences so they can improve experiences, especially like encouraging us to do the class survey and all that because they really want that feedback to be able to improve it for the next cycle. Their [faculty] office hours I would go to office hours every single time, like after the class to make sure I'm up to date on what's going on and keep following up with the classes; them [faculty] being available was one very, very big help.

Serena understood the importance of attending office hours, to ensure she understood the material, as well as to develop a positive relationship with faculty members. Heather studied bio-medical engineering and believed her efforts in class allowed her to obtain support from faculty members. Heather reflected:

> If you reach out to the professor and really participate in class, you guys develop like a great relationship, they'll be able to help you out, and they come and advise us sometimes. If you are just sit there in class do the work, don't go to office hours then you just seem like another student to them. It is kind of, you have to put an effort to get support back.

Heather specifically experienced faculty support in two areas, group projects and research opportunities. She commented:

> Well, they have great faculty support in engineering and they are really focused on group projects. The faculty is really focused on researching and engineering

too, so a professor might ask you to work in a lab a little and then you get more experience and learn more about that particular area in engineering.

Heather also understood the importance of developing positive relationships with faculty and realized it to be her responsibility to create the relationship with faculty. One benefit to the relationship was the opportunity to participate in research with faculty. She understood that this did not happen easily if a positive relationship was not established. Susan always understood the importance of personally meeting her professors and she had a purposeful approached for this effort. Susan commented:

> I come in and I usually introduce myself if it's the first class then they'll be like, "What can I do for you today?" And I'll be like, "I have a question about X-Y-," or if I want to talk to them either about class or life in general. They'll give you pointers about upperclassmen classes, what to look forward to in your career. I even asked them about if I was to pursue a PhD, what are the different career paths that could be available to me? They provide insight to professional career advising and you actually have an advisor of that too.

Susan experienced her faculty support increasing as she moved from her first college year to her senior year. She continued:

> I felt like it [support] increased as you went on. Freshman, sophomore year you had to really seek it out and if you went to the office hours than it was fine but as you became more involved in your major you'll see people in your department

> and they got to know you by name and such. Even walking down the campus now, professors, they know me by name. I'll wave and they'll be like, "Hi, Susan!" They know who I am. It's there; it just depends on how willing you are to get the help.

Susan understood the need to build relationships with her professors and because of this knowledge and effort; faculty knew who she was. Kelsey had no complaints about her faculty members and she believed that respect played a role in a good faculty–student relationship. Kelsey reflected:

> Faculty members so far since my freshman year, it's been great. I can't really complain. Yeah I've never really had bad encounters with faculty. I don't...I respect them. They respect me... ever since that I'm fine with faculty members at this point.

Kelsey believed that once respect was given it was then reciprocated and with this notion she did not complain about her relationships with faculty. Nicole added to support the conversation and talked about her faculty interaction. Nicole stated:

> I've had a couple of professors that I liked a lot, because they were hard on us, and everything had to be done well, but I think that that contributed to our success, and showed that they cared. Like when they want our homework in every day, and they want to see everything that you've done [the homework]. I haven't had as many professors that I don't feel like cared. Once you get into your major classes,

> like your strict chemical engineering classes, I think everyone [faculty] cares. I think in the general engineering classes, there are so many kids that they [faculty] don't care as much. If you reach out to them, and make them know you, then I think that pretty much all the professors are good. For the classes I don't like, I kind of don't really do that. But that's probably when I need to be doing that.

Nicole observed the need for students to develop relationships with faculty member whether they liked the course or not, and perhaps especially, when they do not like the course, because the relationship could advance the understanding. To this point, Simone made sure professors knew her name. She took it upon herself to develop the relationship and she fostered the relationship by continuing to engage faculty in conversation about her academics and career interests. Simone reflected on one professor who made an impression:

> There's one professor who stuck out to me because he always will come to me after class and ask if everything is okay, if there was anything he can do, but that's very rare. Yeah, he was the only one out of all the professors I've had here who'd do that. I am very vocal, like I'm the type of student who'll make sure the professor knows my name, I would go after class and talk, but he was the only one who took an active interest in my academic career, to make sure everything was going as it's supposed to. Some of them, well, most of them [are receptive]. Again, it's rare that you get one who's actively trying to make sure they

> understand you and make sure that you understand what they're saying. It's not just the way that they teach because most students, everyone doesn't understand the way that they teach. They have to come at it from a different angle. Most of them don't want to do that.

Simone recognized that all faculty members were not going to be receptive to her, but she actively attempted to build relationships with faculty. Saran agreed with the suggestion that students had to be active participants in obtaining faculty support. Saran stated:

> I think it [faculty support] was always there, it's just you had to seek it out. It was never ... Yeah, you had to seek it out so it wasn't ... Actually, no. I think junior and senior year I think it might have actually gone up. I felt like more professors actively wanted to know how you were doing in class or in general, so I actually think it went up quite a bit actually by senior year, now I think about it.

Saran realized that faculty support improved as she transitioned from freshman year to senior year. In a different scenario, Aisha had a professor who expected more from the students. Aisha continued by commenting that she enjoyed the experience. She said the professor told the class: "Hey, you're supposed to learn, try to make this motor move and try to make this solar panel work." Aisha, a senior; continued by also expressing her gratitude for three other faculty members and an advisor who supported her. Aisha remarked:

> I have very good relationships with a few of my professors. I can name probably three, I won't name them but there's particularly three who have been very good to me, I'm very grateful for that. Also, my advisor has been very good to me, my academic advisor. He was just very good to me honestly because I had to take two medical leaves of absence this year and almost every month he'd send me a message like "Hey, how are you, I can't wait for you to return." Obviously there are some professors that are notorious but I feel like that's with every place, every department has a professor or two where you're just trying to avoid.

Aisha appreciated the level of support she received from faculty and her academic advisor and used the support to her academic advantage. Lisa also took advantage of faculty and felt comfortable interacting with them. Lisa explained:

> Professors always want you to do well in your topic, so they're actually really pleased when you're able to visit them. If I knew the professor was kind of ... They didn't really want students to come, or they didn't offer study hours, or office hours, then I feel like that'd be an obstacle, because I'd be like, "Oh, they're bothered by me," but it's actually the exact opposite where I feel pulled in to visit because they're like, "Come. Come to our office. If you need help don't wait until the last minute to come," and so that's definitely supportive. Also, professors keep track of people who do well at the tutoring services offered by the TAs.

Lisa also felt that the she established a loving relationship with her faculty and this type of relationship sometimes surprised her. Lisa continued:

> I'd say very loving [interaction with faculty]. I don't know if that's a weird word to use, but sometimes I'm surprised by how much they care. For me, I am part of club activities, so I see some professors outside of class, maybe for award ceremonies or things like that, and when I see them it's like ... For example, I hadn't seen one of my sophomore year professors in a long time, almost a year, and she saw me and we hugged each other, and it was really warm. I was like, "Wow, she remembers me!" All these things, they're kind of just aware of you, having conversations with you and remembering you, so it's never a moment of, "Do they remember my name?" I know that they will, or at least if they don't remember my name they remember my face. And they would end conversations, like, "If you ever need anything you know where to find me."

Most of the women understood the importance of actively cultivating relationships with their professors and Kelsey thought it was important for there to be mutual respect. The purposeful act of reaching out and establishing relationships with faculty was a necessary ingredient for African American women to persistence in their respective engineering programs. As these women advanced to their junior and senior years, they possessed a sense of self and appeared more confident. They also understood the importance and benefit of taking initiative to foster relationships with faculty early

and often. They came to realize that the responsibility to build the relationship was theirs. This relationship building activity was the responsibility of the students because some of the faculty did not create and maintain the student to faculty relationship.

Negative Faculty to Student Relationships.

In direct opposition to the above narratives, Skyler did not have good relationships with faculty. As she took initiative to develop a faculty relationship, he did not make it easy or convenient. Skyler's narrative described the interaction.

> He [faculty member] didn't give a "number two" about being there. He had his office hours between six and seven in the morning, when he would get to work. If you needed help, you'd have to get up at the crack of dawn and that's tough if you're coming from further away. He just didn't care. That really pissed me off. I had to; I had to ask my peers for help a lot because he just didn't care. And that was not a good experience. Some of my teachers were very smart but not good teachers. I think Inside College needs to understand that those are actually two different things. Teaching is actually a skill that you need to respect and learn. It's not like you can just get a bunch of degrees and you're automatically qualified for.

Additionally, Skyler and others thought it was important to receive the big picture perspective from faculty members. However, Skyler did not think faculty members were

successful in providing the big picture view without some prompting [from her or other students]. Skyler stated:

> A lot of the times they [faculty members] would speak as if we [students] already knew the terminology of the field. We don't, we're novices, and we're just getting into it… so it's like I don't really understand what you're saying right now. But also, it's like I don't really get how this fits into what I'm trying to figure out. It was tough having to do that on my own. Sometimes I would just ask them, what does this have to do with what we're doing? Once they finally explain it I'm like, oh, okay that makes sense. But I would have to keep prompting them to do that because they'd get so lost in the details or the terminology, and the methods of figuring it out that I'm forgetting why we're even doing it. I craved for them to understand.

Brandy also had challenges with faculty members and these challenges shaped the manner in which she interacted with faculty going forward. Brandy commented:

> [Support from faculty has gotten worse] because I feel when I first came here I wasn't afraid of professors. Because I feel like, when you do bad in a class obviously you're not going to be, "Hey." They're [coming this way], "Oh God." When I see some of them outside they just avoid eye contact and I avoid eye contact too.

Brandy and Skyler did not have the success expressed by the other women when faculty to student relationship building was discussed. This section focused on faculty to student relationships and through the women's narratives one could posit that the women understood that it was their responsibility to develop and manage the relationships with their faculty. The women understood that this activity was essential to receiving better grades, engineering contacts, and research assignments. The women also had a method by which they engaged the professors and they honed these relationship building skills as they moved from their freshman to junior or senior years. In some cases, one could also posit that the students "made the situation work" rather than the faculty proactively developing relationships. Conversely, two women expressed continued challenges with faculty as they persisted to their senior year and for Brandy, in particular, these interactions negatively affected her academic experience, which presented itself in her demeanor and academic outcomes.

Student Interaction

The interaction with peers is an important factor as students traverse through their academic environment. These women in the study had peers who they considered friends and who supported them in various ways. They also had peers who supported them with homework, in study groups and academically but these individuals were not considered to be friends. The women understood that they, unlike students studying non-engineering

majors, did not have a great deal of time to socialize with non-engineering friends but knew that socializing was an important activity in order to de-stress.

Positive Student Interaction. Situations occurred when support came from individuals that one would least expect. Aisha received support from an academic peer when she really needed it and prior to this interaction, he was a stranger. Aisha recalled:

> There was a class, where I don't like staring at the screen as I said, and this class is all about staring at the screen. I actually have specific glasses to look at the screen because I've got headaches badly. It was just torture to get through it with the headaches. I just had a kid who I didn't even know. He just saw that I was trying and he was so good at the program and he would stay with me until 1 in the morning no matter how long it took me to get it done. I've had experience like that and visa versa, if I can help people out. I know there's a difference, but you have to live with……. You have to make the best of it.

In this narrative Aisha understood that she should be grateful for the assistance and that she was to pay it forward. She also stated that she had more friends in the sciences because they had more in common with her along with similar academic interests. Aisha commented:

> I think that friends in college are based on your interests and the time you have. When you have friends who have the same interests obviously that's great but

> also who understand your time constraints. I can't spend as much time as some other people, I have to do a certain thing, I'm not going to be out all night; I'll probably be in the library so obviously there's that, probably more friends in science.

Aisha understood that her time as an engineering student was limited and had come to terms with the fact that she, as an engineering student did not have the luxury of time like students in other majors. With this understanding came the realization that building relationships with students who had the same time constraints and were of like mind was worthwhile. Simone took this notion into practice and developed friendships with students in engineering. These friends assisted each other with their studies. Simone stated:

> We do a lot of study sessions. Especially now that I added bio-medical engineering, I have to take a lot of the biology classes that they had to take. Since they've already taken them, they help me with the classes. Yeah, I think just being around each other for studying purposes and then knowing when we can't study together because we'll talk a lot. I don't know. They're more supportive and if they go to certain clubs and events they get contacts with people that they think would be good for me, then they'll let me know and vice versa so it works out.

Simone was fortunate in that her friends were also her study partners, similar to Jasmine. Jasmine's experience was similar to Simone and Aisha's in that most of her

friends were in engineering. Jasmine explained that she acquired her friend peers from different environments and most of them are engineers. Jasmine remarked:

> Most of the ones [friends] are in engineering. A few of them are outside, but the ones I spend most of my time with are engineers, some of them accidentally also. Most of them from class or an organization, other ones it was because I guess you just can't escape them. You pass by certain people. I have certain friends that I became friends with them before I had classes with them. They happened to be engineers, which was great because then later on they became study buddies, which was a win. Most of them are engineers, yes.

Unlike Jasmine, Ruby has two sets of friends who supported her. One set supported her socially and the other academically. Ruby described the situation in this manner:

> Most of my friends that I hang out with through social stuff are not engineers, but I do have some friends from the [EXCEL] program who are engineers. Those are my only engineering friends. The first year, everyone's taking the same classes, so we did homework together. We did problem sets together. We studied together. My other friends, sometimes we would study together, but mostly it was to fill a social void. For [EXCEL], we would do our homework together. It's like our schedules match up, so if you're not an engineer, you don't really understand why you can't do this at certain time of day. They understood that.

When Ruby referred to the social void she was referring to the fact that she no longer participated in classes with her friends from [EXCEL] and her non-engineering friends filled that void. She was able to socialize with them as well as study with them; however, the non-engineering friends were unable to assist her with her homework assignments. Susan also had several peer friend circles but said that she would not mix the groups together. Susan reflected:

> My friend circle, the ones I'm really close with, I would say they ... There's a mixture. There were a few engineer friends that I was really close with, I was close with the black engineers, obviously. There were peers within my department that I was close with also. From going abroad I became really good friends with others. I have a mixture but I wouldn't mix the two friend groups, you could say. Outside of engineering I had like a close-knit group of friends too, that I would see every day or every few days. As I went further into my junior or senior year, my major just took over my life. I was mainly with engineers but I'd see the other people I'm close with; some political science majors, some health science and such. They would make sure I'm on task too! If I was lollygagging they would tell me, “Okay ... Bye, Susan!" They would actually come to study with me because they’re like, "I know you will be pulling an all-nighter" so ... If I need to get something done I will put my head phones in, ignore you and continue to do my work.

Susan’s narrative was different in that she had a difficult time building relationships with her peers because some of them did not bathe on a regular basis; or at least look and smelled like they did not, thus her interaction with some of engineering students was short or non-existent. Susan commented:

> Some engineers don't shower so that does affect me. It does affect me because I felt like it was so disrespectful to my nose! It was like, sometimes I couldn't sit in the classroom because it smelled so bad and it made me nauseous. It made me feel sick, I had to leave! That really affected my learning because I couldn't sit next to you or in that classroom because it smelled bad! They just don't shower, it's so nasty. It's one of those "I don't want to be in this environment because it smells bad". They do have a study lounge on campus that is exclusively for engineers but I never used to study there because it smelled really bad.

On the other hand, Susan understood that students needed each other to succeed. Susan explained the situation in this manner:

> As far as engineering it's a collective effort, that's what I'll call it. You need each other. We help each other out, we build off each other. I notice you really can't do it by yourself. There are a few people who can but I notice you really can't do it by yourself. It helps when you do have other engineers, especially in your class, helping each other out supporting each other. You will understand some parts and the other person will understand another part and you could piece it together. If

> you ... I guess for me not going to that study lounge did hold me back because I could have been in that study lounge and probably been able to work better with the other engineers and figuring out things quicker than how I was on my own. The smell, I just refuse. In my head I was like, this place is an abomination, I'm not going there. Some people will stay in there for 7 days straight and I'm like, "Okay!" They would brag about like, "Oh yeah, sleep is for the week, showering is for the weak" and I'm like, "Okay! I draw the line there."

These women had peers they considered friends and who supported them in various manners. These peers represented community members from the larger campus, STEM, engineering, and NSBE communities. Many of their friends came from their Black peer group with not as many coming from their other peer groups. The friends from the non-engineering majors understood that the women in engineering had limited time to socialize due to time constraints placed on them by their academic work load. However, these friends supported them when they could and kept them accountable for their academic success. The women in the study also interact with peers who shared classes, labs and project experiences with them. This academic peer group supported them with homework, in study groups and academically as a whole. Some of these relationships were a means to an end because the African American women realize they needed these peers to succeed in their respective engineering programs. Some of these

academic peer relationships were not positive, but the women had to work with these students in class or on lab teams where they were required to manage the situation.

Challenging and Negative Student Interactions.

All of the interactions had by these women were not positive and some of the negativity focused on unfamiliarity, fear as well as racial and gender issues. Nicole explained that she interacted with a select few people and worked with others if she had to. Nicole commented:

> I don't really talk to people much. Like I said, I have my 3 or 4 kids that are in all of my classes that I talk to, and we're friends outside of class, but besides that, I don't really talk to people in class, at all. I'll talk to people if I am working on a project with them, but afterwards, I don't really speak to them.

Nicole chose to interact this way because it was comfortable for her. In fashion, Lisa, admitted that she had to overcome her fear of asking for help from her academic peers. Lisa revealed the following:

> I think, just because of my own mentality, if I'd decided sooner to open up [to my White peers] then it would have been a lot easier, so overcoming my own mentality in order to not be afraid to be like, "Hey, send me your lab report because I know you got an A on this. I just want to compare with mine," so I think it was just overcoming my own barriers.

Lisa continued and commented that she had to overcome her fear of asking for help and alter her approach. She commented:

> I think after changing the way I approach my peers, I feel that they're a lot more open and willing to work together or share experiences. I know at the beginning I kind of felt like, "I don't really want to." I was just kind of paranoid that, "Maybe they're better than me or they think that they are, or are they," or whatever they thought of me, so after a while I just was like, "Hey. How are you? Did you get this problem?" If I see them around I'll just be like, "Hi. I acknowledge you as my classmate," and not pretend that you're not in the same class as me.

Lisa decided to devise a solution to reduce her fear and this plan was successful. Susan was another woman who had to overcome the fear of participating in class discussions whether it was to ask a question or provide an answer to a question. Susan stated:

> Sometimes I would ask some questions and I was hesitant about asking in class so I would go to Office Hours and ask there. As I became an upper-classmen I got over that fear of asking questions in class and would just say it out loud. I was like," Could you go back to that, what did you do there?" It made sense. Slow it down for me, fine. You guys could be mad, I don't care anymore. It's my learning now.

Fear was one feeling experienced by a few of the women, whereby, Brandy shared her narrative with a more complex issue requiring a more complex solution. Brandy experienced a highly segregated academic atmosphere. The White men tended to group themselves off into teams as did the White women. Whoever was left would group together and this had been her experience. Brandy stated:

> It's been that way [segregated] since we started taking chemical engineering classes, even when we have to separate into groups. I'll tell my, one day I was talking to my old advisor about it. I was telling her what group I was in. She was, "Wow, are you guys still segregated?" …because it was four other Asian boys, one homosexual boy and me in the group. I was like, "We should call ourselves the outliers because all the other groups are White kids." People don't do stuff on purpose. Of course if there were other Black kids in the class I would gravitate towards them. You can't just slight people for that. I understand, to an extent. I just feel it's not inclusive at all.

Brandy's environment was chilly and unwelcoming but it was not much worse than Heather's narrative as she mentioned incidents where some of her academic peers thought she was not qualified to be in the engineering program. In the beginning of her academic journey, the White students did not think that she belonged in the engineering program with them, until they determined she was out performing them every time. Heather explained the situation in this manner:

> I’m used to being the only Black person in class, right? I don’t think anything of it whatsoever and then I just, it is kind of they don’t judge you at first, well; actually they do judge you at first. They probably don’t think I’m as smart and everything until I get that test back and I beat them. I mean it happens all the time. I got a scholarship for coming here, mine are purely academic and they think that I got a scholarship just because I’m Black. The problem is that this school was my safety school and they gave me so much money that I couldn’t say no. When people tell me that I just got in because I’m Black, I’m like you don’t even know, like I blew the academic requirement out of the water. It is just …Yeah, it is insulting.

Heather overcame the stereotype of not being academically prepared because she outperformed her peers and once they determined that she was more than capable, another phenomenon occurred. Those same students wanted her help. Heather explained: ‘People always ask me for help. Okay, you can ask me for help, but I’m not helping you on everything. I’m not doing it all for you.’ Heather had to now balance the art of being collaborative without allowing her peers to take advantage of her. Skyler had to determine the situations that warranted collaboration and the situations that did not as well. In this narrative Skyler mentioned an experience where she had to self-select herself out of her peer group. Skyler commented:

> Everyone [students] got together one day, there was like a take home test and they were all, we just all were there. It wasn't like they were trying to exclude me; it's

> just that sometimes I didn't join them. That's partially because, sometimes they would cheat a little bit and I wasn't into that. I had to…I'm not going to learn anything from that. I had to monitor when I would go.

In one of the incidents when the other students in the class were cheating, Skyler had to make a conscious decision to either study with the group and pass the test, because they had the answers or study by herself and take the chance of failing the test. She decided to take the moral high ground and she studied on her own. She unfortunately failed the test and was the only person in the entire class who failed the test. Her next dilemma was to keep the secret or tell the teacher about the cheating. Due to the peer to peer environment she decided to keep quiet and thus jeopardized her academic scholarship. However, she persevered through the experience and continued progressing ahead.

Skyler's study groups experience jeopardized her academic standing. This was an extreme situation. However, study groups could pose challenges if you do not understand when and how to use them. Jordan was concerned about studying in groups because it was not always effective. Jordan commented:

> I usually stick to the same people I know. Most people do too. Every now and again and there might be some huge study group or something, I might know one or two people and everyone just gets together. I don't really go do those as much though because I found that those huge study groups are really not super effective

> because everyone just ends up talking or complaining or it takes twice as long to do. I like a smaller group where you’re not spending your study time [being unproductive].

Even though Jordan tended to collaborate with the same people, as she discussed in her above narrative, she strongly believed it was important to develop relationships outside of her comfort level. Jordan went on to say:

> I think it’s also important to be able to make friends outside of NSBE. Sometimes, they [NSBE members] get caught up in, “Oh, I can’t relate to other people.” It’s like, “Well, you have to. That’s not what the workplace looks like.”

Jordan suggested that African American student should develop friendships outside of NSBE, and their comfort level. However, Lola suggested that it was sometimes challenging because she did not know how Black she was until she experienced the White privilege in college. Lola commented:

> Most people are from this area, and they've never seen people that don't look like them. The whole privilege thing was a big thing. I'm not used to that. From my [home town], it's diverse. I never realized how Black I was until I came here. It's thrown in my face all the time so I'm just like, "Wow. You guys are weird."

Lola continued on and remarked: “I kind of envy them [White students on campus] a little bit because they're having the time of their lives. They're meeting their future fiancées and husbands”.

Kelsey’s narrative is similar to Lola’s in that it speaks to the racism that was perpetuated. Kelsey remarked that some of her White peers did not know how to interact with her and that they were afraid of her. Kelsey stated:

> But there's a lot of people that you deal with that don't know how to deal with you and are scared of you honestly. I think as far as my race, like I said, I think a lot of people are scared of me on campus. Frightened, they don't know how to deal with me or African Americans or people of color because they can't relate and they don't...some of them don't want to relate. Some of them don't want to understand. I mean I've heard derogatory terms said on my campus, and had to prove myself to be worthy to go at that school.

Kelsey also encountered experiences where she was not being taken seriously because she was a woman; where she was surrounded by and working with men. Kelsey continued:

> I would say as far as my gender I think it does play a role especially in engineering being the only female. Especially being a minority within a minority. They don't take you as seriously sometimes, but you have to, especially if you are in an all guys group, and you're the only girl. You have to have more of, not a

> chip on your shoulder, but more like, "I'm here to work and I am going to make my presence known". And I think you have to be very outspoken and make sure that...I feel like I've always had to try harder than the average Middle College student.

Aisha suggested that racism is real and we should be honest about the state of racial attitudes and misconceptions. Aisha stated: “Let’s be honest. The field, it’s mostly dominated by Caucasian males and I found like, yes, in some cases people don’t want to be nice until they see the grade on your paper."

Susan expressed the fact that this college environment has taught her patience. She states: “Like I said, it taught me patience. It taught me about learning to be comfortable in an uncomfortable ... Something I'm not familiar with.”

Aisha and Susan were well aware of negative racial environments, and supporting this narrative, Brandy compared how she felt about being the only Black person in her class to how she believed her White peers feel in the classroom. Brandy stated:

> They’re all White but they don’t think about race that when they go to class. I thought about that for a while. I feel like this is an unfair burden that’s placed on me. When I was walk into class, I think about all these things. Being black, being blah, blah, blah, and they walk in class like, “What are we doing in class today?”

Additionally, Brandy’s classroom experience was negative because she felt ostracized in the class; thus, she did not participate in class and at times, did not want to

continue in engineering. However, her determination not to quit compelled her to continue her academic journey and graduate with a chemical engineering degree. Brandy explained the situation in this manner:

> Honestly, it's been so long since I was talking in class. The last time I talked in class is probably fall semester of my sophomore year. I feel like they're [her peers] all wolves. It's not been better, but there was a point where I really felt I was walking into a room of wolves.

However, Brandy continued on towards degree completion and in her senior year she participated in an internship assignment. Due to her academic experiences, her goal to be an engineer has been altered as she realized she wants to focus on other areas, but she utilized her knowledge to leverage another type of career trajectory. Finally, Lisa was aware of the stigmas place on her due to her race and gender. Lisa discussed her thoughts about it in this manner:

> I think the biggest role my race and gender in general played was just being aware of being a minority and aware of stigmas or status quo, and lacking confidence because you're not sure how to measure up. It's really easy to beat yourself down and think, "I'm not good enough," or kind of just get stuck on that and not move forward. Actually, it would make me afraid to speak up, or afraid to say an answer and contribute in case what I say is wrong, and that will be like, "I'm proving to all of them that I actually am not able or competent," or whatever, so after I kind

> of ... There was a point and time when I was like, "Oh, whatever. I don't care. I'm just going to say my answer," because after a while you kind of realize that, "If I had raised my hand I would have been right. Actually, I had that same idea too or whatever. After a while I was just like, Let me just try it," and it's hard, because I am wrong sometimes and it's embarrassing, but then you get over it, and you keep climbing, and then you're right after a while.

Throughout the narratives presented by the women in the study there were many examples of racism, sexism, stereotype threat. Within the scope of self-efficacy, these women pushed through the challenging situations that tested and strengthened their self-efficacy. Through their self-efficacy they honed their learning prowess and defined their science identities as well as academic achievement goals.

They ultimately believed in their capabilities, but sometimes the environment or circumstances tested these beliefs. This self-doubt forced them to compose themselves and re-committee to their academic journey. This is evident when you examine Brandy's narrative describing how she felt ostracized in her classroom environment or when Kelsey mentioned that her White counterparts were afraid of her and did not take her seriously because she was a woman in an environment dominated by men. Self-efficacy, "refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1986, p.3) and all of the women in the study exhibited this trait. This is evident because they continued to persevere and

overcame obstacles as well as failures. They were resilient and successfully persisted toward graduation.

Collaborative and Competitive Climates

As I listened to these women share their stories, I concluded that some of them did not adopt a sense of belonging in the larger engineering community, but were successful in finding smaller peer groups that fulfilled the sense of belonging they required. Along with the sense of belonging it was important to determine if the academic environment is collaborative or competitive, because this environmental trait contributed to the sense of belonging. Most of the women believed their academic environments were more collaborative than competitive, even though some said that the climate began competitively. Simone stated that her environment had always been more collaborative than competitive. Simone stated:

> I will definitely say [my academic environment] is more collaborative. Yeah. I don't think it's ... I mean, it's competitive, but it's not as you would think. Everyone isn't like gung-ho, trying to get to the top grade or whatever. Everyone is helping each other out. Especially if you have friends in your class and they know. It's a lot of group work that wasn't necessarily assigned by the professor, we just place it upon ourselves to the group work, yeah, definitely more of a collaborative culture.

In Simone’s situation, there was a healthy atmosphere of competition and in Lisa's narrative, she expressed that fact that collaboration has grown. Lisa remarked:

> I'd say that there's a lot of collaboration, at least as my class. I think it’s grown. I think at the beginning, it definitely could be competitive, but after a while you realize that you need other people's help, so it's definitely a lot more collaborative. …Months before an exam, I think the whole part of the second floor is just all people from my class, and we're on the board trying to see, "Hey did you get this problem?" and people are just passing through and we're like, "Hey, did you get this?" so that was really nice and I was really happy about that. That was totally different than the start of the school year, because we're kind of maybe afraid to show their weaknesses.

Lisa’s situation demonstrated how obstacles and challenges brought individuals together to solve problems and these obstacles produced a more collaborative environment. Mary’s narrative is akin to Lisa’s situation in that students discovered they could not complete certain academic tasks on their own and that they had to work together. Mary believed the culture to be positive; however, she explained that everyone started out working alone until they experienced academic roadblocks. Mary stated:

> I feel like everybody is doing their own thing. It can be funny at times when somebody doesn't understand something and they think they're the only one and then somebody else comments like, "I didn't get that either." Then everybody just

> starts the whole conversation about how they didn't get it and they thought they were the only ones. I feel like it was welcoming, like, "You're not alone." I think the culture is good overall.

Mary experienced a collaborative environment and Ruby shared similar sentiments and expressed the following:

> The engineering school, I wouldn't say it's competitive. I don't think we're a very competitive school and you don't really compete against each other. It's very collaborative. It's pretty social amongst each ... All the EEs, the ECEs, since it was just one class of us, we all know each other, and we all do things together. It's also environment where you were involved in a lot of different things outside of engineering.

One can posit that an environment where students engage in other activities together would be an environment where collaborative activities would occur and this seemed to be the case for Ruby and her academic setting. Juxtaposed the above collaborative narratives, Nicole and Brandy had experiences where their environments were competitive. Nicole experienced her academic atmosphere in a different manner and believes it to be competitive; however, it did not affect her and her academic success. Nicole commented:

> I guess I would say competitive, yeah, probably competitive. I don't know that's kind of hard. I don't think it affects me as much as it affects other kids. I think that

> some kids, this is like their whole life. They're completely invested in their classes, and I guess more competitive to them. If it was that competitive, I don't think I would feel it as much. I think I'm more about my own work than noticing how everyone else acts about it.

Nicole mentioned the competitive nature of her environment, but she also stated that the environment did not affect her because she was focused on her academic and knew what she had to do to be successful. Brandy encountered the most challenges in her engineering environment. The climate was chilly for her, thus, she experienced and observed her situation differently from most of the other women interviewed. She did not believe her peers to be collaborative at all and she felt alone when she had to interact with her peers in academic settings and they did not seem to want to include her in the academic activity. According to Brandy:

> The chemical engineering department is definitely not inclusive at all. I feel we’re the most dog-eat-dog department. I've heard from my friends who are other majors that when something is hard, the whole class gets together and figures it out. In our class, it’s "I figured it out and I won’t tell you guys because you guys are going to mess up the curve." We’re like, “You’d really do that?" It’s been that way since we started taking chemical engineering classes, even when we have to separate into groups.

Within their narratives, ten women described their environment as collaborative, two described it as competitive and two others thought that their environments were both collaborative and competitive. These collaborative and competitive sentiments crossed the five institutions involved in the study and did not stem from one institution or another due to size or culture.

Science Identity

The women described the manner in which they viewed themselves in their academic environment as it pertains to their science identities. When asked, fourteen of the women described themselves as having a science identity. This identity is related to their self-efficacy in that one strengthens the other. Three identifiers are described within the science identity model: a research scientist identity, altruistic scientist identity and a disrupted scientist identity.

Research Scientist Identity.

Fourteen of the sixteen women interviewed for the study consider themselves to have a science identity. Reviewing the sixteen women and their descriptions of themselves, six women described themselves as engineers; six women did not describe themselves as engineers, two women where indecisive and two did not comment as to being an engineer or not. The women described themselves as having a science identity,

believing they are competent in their scientific knowledge and being recognized by their peers and faculty for their competence. Additionally, the knowledge they acquired will enable them to thrive in their next endeavor whether a career or graduate program. They all believed they worked hard in their majors of study and earned their science identity.

For instance, Mary enjoyed solving problems and believed the true test of her science identity will be demonstrated through real world applications. Another example of this identity behavior was seen in Serena because she applied what she learned as an engineer in her everyday life. Additionally, Heather believed she had a science identity but believed that her peers and faculty members did not believe she had this identity until they saw her work. Prior to them seeing her work they believed she was there just because she was African American women, however, once they saw the work she was producing their opinions changed and they began to see her as having a science identity. Mary believed she possessed a science identity and believed that her faculty realized her competence as well. Mary stated:

> Yes, I believe I have a science identity, I enjoy coming up with creative solutions to just about any problem. I believe I am competent in engineering knowledge and if there's an area where I feel that I need more work on, I am very good at finding library and internet resources that are helpful. I would say my peers and faculty believe that I am competent in engineering as well. I think that I am competent

> although a better show of that is real world application, but my professors would say that I'm competent and able.

Mary believed in her competence as a scientist and also believed she was recognized for her competence by her professors. Serena shared this sentiment and believed to have a strong foundation in engineering that grew. Serena shared the following:

> I do believe I have a strong science identity and find myself applying ideas or knowledge I have in my everyday life. It has also enabled me to think critically about things and analyze situations in a realistic way. I do believe I have a strong foundation in engineering fundamentals, but I still have a long way to go in my search for knowledge hence my decision to attend graduate school. I do believe that my peers and faculty members believe in my competence in engineering as they have all supported me in my decision to further my career and believe that I can achieve great things.

Serena had a science identity and believed that her faculty and peers believe she had one as well. Heather also considered herself to have a science identity, but she was not confident in knowing what her peers and faculty would say. However, she knew her work spoke for itself. Heather remarked:

> I consider myself to have a science identify. I feel that peers and faculty members are unsure at first, they may not see that I have a science identify, but once they see some of my work they believe in it too.

Women with a research science identity recognize themselves as scientists and convey enthusiasm for science focused information, practices and career opportunities. The fourteen women in the study recognize themselves in this manner and were excited and enthusiastic as they grew their science knowledge. These women also experienced science "as an exciting way of knowing" and believed in science for science sake, focusing on the natural environment (Carlone & Johnson, 2007). The women in the study believe in their science identities because they continued to be successful in their engineering majors and they enjoyed the material they were learning. Some of the women took this identity further demonstrating altruistic science identities, behaviors or interests.

Altruistic Scientist Identities, Behaviors and Interests.

The women, who viewed themselves as engineers who "wants to be able to improve someone's life" or "impact the community" can be described as altruistic scientists, who create their own explanation of science, re-frame whose recognition is significant, and at times, re-frame the meaning of being a woman of color interested in science. The women who resonate with an altruistic science identity used their interest in science to serve humanity. The interpretation of their narrative is at the end of this

section. Jasmine was interested in making a difference through science and identified with this altruistic distinction. She continued:

> I think it was a combination of things. I liked the idea ... I really have this romantic idea of how an engineer is basically someone who just has the tools to ... They just are able to apply all the school's theory, all these things with theory, with math and science, to improve something, sustain something, or invent something new. I liked the idea that I can be doing something that can be improving someone's ... I just like the idea that I could be ... I can play a role in improving things.

Jasmine wanted to improve someone’s situation by utilizing her engineering knowledge. Serena, a senior studying chemical engineering at Upper College was also interested in making a positive impact on the environment and will spend another four years preparing. Serena commented:

> Right now, I'm graduating and I am pursuing a PhD in Chemical and Biomolecular Engineering at [Chemical Institute of Technology]. That's another four years of my life that I'm dedicating to engineering, but I'm excited because I feel like there's so much more than just being a work bug and there's so much more I could do if I could do my own research and actually provide something that would impact the community or the environment even more.

Jasmine and Serena purposefully prepared themselves to make a positive impact on the environment using their science identity and their efforts in concert with what it means to possess an altruistic scientific identity. Additionally, Heather has prepared to follow a medical path to become a doctor while Simone and Aisha want to focus on bio-medical engineering and Nicole plans on studying tissue engineering; all to provide a service to society. None of these women thought of their engineering degrees as a means to an end; instead, they viewed their degrees as foundations for societal contributions.

Disrupted Scientist Identities.

If a woman feels she is not recognized or is recognized as a member in a stigmatized group then she could have a disrupted scientist identity. Brandy was the one woman interviewed who was emphatic when she discussed her lack of a science identity. Her experiences at her first college institution and in particular her present institution shaped these feelings and these feelings were not positive. Brandy asserted the following:

> No. It's crazy, but I feel like I definitely had that identity [science identity] way more before I even came here, maybe in freshmen year too. But when people say things about engineers I roll my eyes…okay, here we go again. So no, [I do not have a science identity].

Brandy became disillusioned about engineering and the pursuit of an engineering degree due to the chilly climate she encountered throughout her academic life at Upper

College. She had no interest in being an engineer and only completed her degree as a means to an end. Brandy's narrative could be interpreted to conclude that she was "discriminated against by meaningful others within science" and was recognized as a member of the "stigmatized groups" (Carlone & Johnson, 2007, p. 1202), and this recognition along with her resulting reaction caused the disruption in her science identity.

All of the women, with Brandy as the exception, resonated with the belief of having a positive science identity. As an example, one could argue that Jordan and Serena have achieved a research scientist identity because they considered themselves to have one; their faculty and peers recognized their science identity and they received national and international recognition acknowledging their scientific accomplishments. With the recognition of their science identities, whether research scientist, altruistic or disrupted, all of these women developed career goals.

Career Goals

All of the women had future goals. Whether they were focused on graduate school, research or starting their working career, they all had some plan in mind. These goals grew out of their academic experiences, both positive and negative, and their own interests. Heather planned to become a doctor. She stated:

> I'm pretty set on being a doctor; we'll see. I still like the research aspect and the engineering aspect, so just hopefully I get to bring those aspects into being a

> doctor so that is why I was looking at orthopedic surgery because you get to use those skills. I'm taking a year off after. Well, I'm going to apply next year to medical school. Then I have a gap here so I will probably be in a research lab hopefully gaining a little of money and then go to med school, do my residency. I don't know if I want to be part of the US Navy or the US Army when because they pay for medical school.

Heather had her goal set on becoming a doctor and she needed to determine the best course of action to accomplish her goal. Similar to Heather, Simone and Aisha were both focused on the medical field with a specific focus on medical devices. Simone concluded that she wanted to continue on into the bio-medical field and needed a graduate degree to reach this goal. Simone commented:

> Definitely a working path... definitely. I like to research, but I don't think that's something that I want to do. I did a research experience for undergraduates this summer after my freshmen year. I mean, it opened me up to different opportunities, but it's not something that I would want to do. Then when I got on [my internship] and I decide I wanted to go to more of a medical field. I came across John Hopkins and everyone knows it's great for a medical school. Right now, based on research and my own tinkering and projects that I do, I think that I want to work in neuroscience and do the bio-medical devices for the brain. I think that's what I'm leaning towards now just because it's interesting and I like it.

Heather had the opportunity to explore different career options and developed her career path, like Aisha who wanted to focus on the bio-medical field. However, Aisha had an opportunity to work in the petroleum field, which was not her field of choice, and this caused her to decide the best course of action. Aisha stated:

> When I started getting into the more bio-medical side and I added biomechanical as my minor then that's what pushed me to say, "Hey, I would love to work at [BioMedCo] at some point." [However], I was supposed to go to [another country] and work at [an energy company] which is the oil and petroleum offshore thing there. I'm reconsidering that at the moment just because I was just having a discussion with a friend the other day. He was telling me that sometimes it's a little bit harder to switch industries in the sense that …. He was just saying that if I want to be in the biomed industry it would probably be nice to start from now necessarily.

Aisha had to determine if she was going to select instant gratification and accept the oil and petroleum position or focus on her long term goal in the bio-medical field. Nicole was also interested in bio-medical engineering, specifically tissue engineering and contemplated the master's degree required once she starts working. She described the situation in this manner.

> I'm interested in tissue engineering, weird stuff that's coming up, new engineering technology within that. If I could find something like that, I

> think I would love it. Maybe do research for the rest of my life. I know I don't want to be in an office setting. I don't know about grad school. It's something I need to start thinking about, but I'm not sure about that. Yeah, you're supposed to. I don't know. Maybe once I start working, and I'll try and have my company pay for it[graduate school], but I don't think I'm going to go straight into grad school, probably in chemical or bio engineering. I'm trying to do a behavioral neuroscience minor.

Nicole was unsure of the path she wanted to take but the end goal was to work with the brain, potentially through research. Ruby and Lisa were unsure of their career directions, unlike Heather, Aisha, and Nicole, and they were using additional education to figure it out. Ruby was potentially interested in a master's in engineering or engineering science and Lisa wants to pursue a PhD. Ruby worked through her many interests and concluded the following:

> When I first started college, I thought I was going to be doing Bio-medical Engineering, and then I thought I was going to be doing Biotechnology. I thought I was going to be doing research. I thought I was going to work for a technology company, making devices. I thought I was going to be a geneticist. I really go around a lot, so I guess I'm still figuring out. It's hard to know what you want to do. Center College has a really good engineering management program, so I've been looking in to that. Maybe I would do that, the masters in engineering,

masters in science engineering management, but with that program, you don't really go right after school.

Ruby entertained many options to determine her career path. Lisa was in a similar situation in that she was interested in pursuing her PhD; however, she was not sure of the subject matter. Lisa commented:

> I'm 80% sure that I will go to grad school and try to get my PhD. I'm not sure yet [in what]. I just know that I'm not ready to go into [the workforce]. I just want to know more about what I'm interested in, and then [want] to pursue that. Hopefully within the next few years I'll figure that out.

Ruby and Lisa had educational and career decisions to make. However, they acquired solid undergraduate degree, along with some work experience to use as their foundation. Jasmine also explored several options; however, each option had engineering as a component. Jasmine stated:

> I would like to go into something more specific just because of that romantic idea I have about being a special, like being an expert in a certain field. I just don't know what yet. I do know that higher degree, I do at least master's. I would still want it to be in engineering. Beyond that, I don't know.

Mary worked with a three-step strategy to determine her career direction. With this strategy, she continues on her academic path and pursues a master’s of science degree in mechanical engineering and then determines what career path to take. Her goal

is to stay technical, but she is not sure in what direction. The one thing she is sure of is that she would like to obtain experience and then start her own company. Mary remarked:

> After graduation, I want to get a full-time job [in engineering] somewhere fun. I want to work somewhere new and exciting where you're solving problems that have never been solved before. I don't want a run-of-the-mill job where it's like, "We're just editing these drawings that's been made 100 years ago." I want to do something new and exciting that challenges me every day. I really, really want to have a startup so that's one thing. Academic wise, I just want to ... I want to do well. I just want to, like I said, start my own business, branch off. I do want to work for regular Corporate America, but at some point I want to go on my own and not stay under someone else's umbrella for the whole entire of my career.

Mary was focused in knowing that she wants to operate her own company in the next ten years and will use her work experience to obtain the knowledge to manage the business. Skyler does not want to own a company at this time, but she does want to remain in engineering and is focused on alternative energy. Skyler remarked:

> I like companies that do defense stuff. Even though they're making weapons, and that kind of sucks, they also have, in the corner, their alternative energy departments. Like Sandia Labs, for example, outside of San Francisco, or like, there are a couple of others I was looking at the time. Learning newer materials that are better or nano technology and how that would help. All that stuff looks

> really interesting and, because I have a better sense of what I want to do, I know that I'm probably going to have to go back to school.
>
> Do a focus in material science or chemistry or something like that. I'm still working toward that goal. Right now, because I had issues trying to find work in the alternative energies field, because I was stubborn too. I graduated with a 2.8 or something like that, which is pretty low for a lot of people. I'm sure that deterred some of them. Actually, that's the reason why I didn't get a job at Sandia Labs. They were getting ready to give me a job. I had been talking with them, all and the faculty. I was this close. This close, and then they asked me my GPA and then they reneged. It broke my heart. I hope to get into alternative energy. That's what got me through school, the hopes that I would do it.

Skyler has experienced some challenges in reaching her goal of working in alternative energy, but she continued to strategize ways in which to accomplish this goal. She relocated to a part of the country where she will have better opportunities to realize her goal.

Saran focused on an engineering career path in aerospace engineering, her number one priority. Saran stated:

> Initially my plans were to go to graduate school for Aerospace Engineering but that didn't work out. I didn't get into any of the schools so I'm still very interested in Aerospace Engineering, but I feel like getting a job is probably number one

> priority right now and eventually hopefully I can go back to school and get that Master's Degree. Right now I've just been applying to entry level Mechanical Engineering jobs and trying to just get settled and have my money and have ... Start the next part of my life.

Saran, like Skyler, was in the process of securing an engineering position in her field of choice. Brandy explored other avenues due to the fact that she did not want be an engineer. Brandy commented:

> Seeing as I don't want to be an engineer at this point. That's just how I feel. I've applied to a wide range of positions so I'm doing research. One is for a financial, a business analyst. One is for a technical consultant. I'm just dipping. One idea was to get a graduate degree in something that's completely off, completely whacked off which I don't know. I still need to think more about that. Another thing would be an engineering management degree which may not really happen. I feel the only way that would happen is if I got a job out of school and then they were willing to pay for the degree.

Jordan wanted to move away from civil engineering and focus on other areas. She explained it in this manner. "I think I'm going to go into graduate school, but to do industrial engineering or operations research, something like that". Jordan was awarded a prestigious scholarship and will fulfill this goal of pursuing graduate studies. Kelsey wanted to work for at least a year and then obtain her MBA. Kelsey stated:

> I want to get work experience and I want my job to pay for it. So I would like to get in the work force, work...I would love to be a project manager. I would love to do...get project manager certified, take the test and be a certified project manager. And get my MBA. And then see where life takes me at that point. Those are my goals for right now.

Kelsey's short term goal was set; she wanted to secure her MBA and become a project manager and then reassess her situation. Lola had a more long term goal of leading a multinational company enabling her to assist and influence Black communities, low-income communities and developing countries. Lola remarked:

> I think I'm going to go the supply chain route and try to ... my overarching goal is to be some type of top executive at a multinational company, so I like big conglomerates. My overarching goal is to get power, to become like an executive on a company so that way, I can have influence because I want to indirectly influence the Black community and low income and developing countries, like to work on projects or to ... My plan is to just get enough power so that way I can influence the community, especially the Black community within the US, and then to work with developing countries.

Lola remarked about building a company with a mission of positively influencing communities in the US and in developing countries because giving back to society on a

grand scale was important to her. Susan wanted to work on her master's in business as she decided if medical school was in her future. Susan stated:

> I plan to attend graduate school doing a business. At first I wasn't sure. I'm using this year as a gap to figure out whether I want to go to medical school or not. My original degree was, at Lower College was bio-medical engineering with [a concentration in technology innovations so that's running the business side of engineering.

Kelsey, Susan and Lola wanted to concentrate on the business side of engineering focused on managing projects, as well as owning and operating a large company. These women continued to shape their career goal ideas and their education supporting these goals. All of the women's hard work, self-efficacy and motivation have prepared them for the next step in their career journey. Most of them knew the direction in which they wanted to travel and the tools needed to be successful. Their next steps could prove to be as challenging as their college experience but in spending time with them and getting to know them, I was confident in their success.

Responses to Racism and Sexism

Through all of the academic success, the women in the study faced or witnessed racism and/or sexism. During these encounters, the women responded in different manners and some did not respond at all. However, all of them expressed their belief that

both racism and sexism existed in their academic environments. Nicole did not think racism and sexism affected her academically. However, the fact that she was the only African American person in her class did affect her socially. Nicole commented:

> I think that a lot of it is probably myself. When I go into a classroom, and I'm the only black person, I'll probably just kind of keep to myself more. I don't think I've been openly treated different. Not that I've noticed. I don't know. It just would be something that I notice, but I'm also kind of use to that. It's not something that would like ... I don't think it affects my learning at all. I think I just realize it.

As Nicole mentioned, she did not believe she was treated differently due to her race or gender. However, the fact that she was in the minority made her respond by keeping to herself. Ruby's response was also social in that she was not able to develop friendships with her peers. Ruby described:

> Yeah. It's distracting. I remember in my ECE classes, there were very, like a lot of guys, so it's not the same ratio for chemical and environmental. There are a lot of girls, but in our class, there are 5 girls. Two were Asian, two white, and then there was me. It was rough. It was hard. It was overt in the fact that none of the students became a close friends in those ... I could never be friends with the people in the class. It just wasn't the environment.

Even though there were five women in one of Ruby's classes she was the only African American woman and felt left out. Simone was also the only African American

person in her class but she expressed her response differently than Nicole. She was motivated and felt pressure to perform well. If she was absent from class the professor would follow up and even though she appreciated the gesture, this action pressured her to perform well. She also felt she represented other African American students and other African American women and this produced added pressure. Simone stated:

> The one thing that I will say that's a positive is, because I'm the only black face in the class the professors can't help but to notice you. I mean, if I'm not there, they'll notice. I might get an email, "What's going on," if it's one of those professors who were actively involved. Yeah, you definitely are noticed. It kind of puts a little bit more pressure on you because you know that you're the only one there. It's kind of like you represent the rest of us even though they're not even in the program, really, but you just think that you have to be ... So you have this good representation. I think that definitely also plays a role in my being motivated to do good at this school just because I'm African-American in this field and a woman. That is definitely is a motivator. Most definitely, definitely a pressure. It makes you want to work that much harder and then say you don't necessarily succeed in something that you're trying to do. It kind of is that much more of a downer, much more disappointed if you didn't get to where you wanted to go.

Simone responded by being motivated and pressured because she had to prove herself and felt a responsibility for all other African American student and did not want to

let anyone down. This added pressure could be detrimental depending upon the manner in which a student internalizes it and Simone used it as a positive pressure that was not detrimental. Kelsey also felt she had to prove herself and make sure she was heard when she participated in group work with her classmates, who were mostly men. Kelsey framed the situation in this manner:

> I think as far as my race, like I said, I think a lot of people are scared of me on campus. Frightened, they don't know how to deal with me or African Americans or people of color because they can't relate and they don't...some of them don't want to relate. Some of them don't want to understand. I mean I've heard derogatory terms said on my campus. I would say as far as my gender I think it does play a role especially in Engineering being the only female. Especially being a minority within a minority. They don't take you as serious sometimes but you have to, especially if you are in an all guys group and you're the only girl. You have to have more of, not a chip on your shoulder but more like, "I'm here to work and I am going to make my presence known". And I think you have to be very outspoken and make sure that...I feel like I've always had to try harder than the average Middle College student. And had to prove myself to be worthy to go at that school. So I'm not...exactly. So yeah I feel like I had to prove myself, being a person of color and being a female.

Kelsey's environment provided her with situations that decreased her sense of belonging and forced her to prove herself and work harder than other students. This type of environment could deter African American women from persisting in engineering if other support mechanisms are not available. Brandy began fighting the racism and sexism by trying to prove herself, but the fight wore her down. Brandy reflected:

> It [racism] would just motivate me to do better. For example, you get the right answer, no one listens to you. Five minutes later, they tell you the answer that you gave them five minutes ago, stuff like that. It just propelled me, "I'm going to show you all that I'm so much smarter than you." Here it still liked to happen and I was, "You know what, you got it." I basically shy away, stay in a corner and not feel.

The chilly and unwelcoming environment caused Brandy to prove herself and fight against racism. However, this constant battle took a toll on Brandy and her response shifted to avoidance where she avoided as much of her academic environment as possible.

Saran did not experience sexism; however, she did experience racism. Saran's response to racism was internal and at times it would affect her academic performance.

> Being a female didn't seem to play a big role in my class while we were a minority it was very close, the ratios. Being a student of color, I definitely had days where I felt like it affected my performance but I think it was definitely on a

> personal level. There would be days where I would notice or it would occur to me that I was the only person of color in a class and then I think that personally affected me for however long.

Over time, Saran understood that she should not allow these feeling to affect her academic performance but she also expressed the fact that it "was easier said than done."

The women discussed their responses to race and gender, but most of them focused on race as the factor that caused the most challenges. Kelsey, however, did have significant challenges due to her gender. Moreover, some of the women mentioned they were used to being the only African American woman or only woman in the room or groups, but this continued state of affairs still affected them in some manner, most of which was negative. The women also responded differently. Some of the women had reactions that they internalized while others expressed outward reactions, all of which were potentially detrimental to their academics and sense of self.

CHAPTER 6

DISCUSSION AND CONCLUSION

In this study, I set out to examine and bring to light the experiences of African American women in undergraduate engineering programs at PWIs. I accomplished this by interviewing sixteen African American women juniors and seniors who are studying engineering. During the study interviews, eleven women were juniors and five women were seniors. Five institutions are represented in the study. Nine women attend Upper College, one woman attends Lower College, two women attend Center College, three women attend Middle College and one woman attends Inside College.

The conceptual framework used for this study consisted of Weidman's (1989) undergraduate socialization model as the underpinning with Delgado and Stefanic's (2001) CRT providing the overarching discourse. The undergraduate socialization model provided the outline for data gathering and analysis for the study focusing on background characteristics, parental socialization, non-college reference groups, pre-college pressure, in-college pressure and socialization outcomes factors. However, the undergraduate

socialization model did not provide a mechanism that considered or analyzed race and racism.

CRT was used in this framework to infuse the undergraduate socialization model with four CRT tenets: racism is ordinary, not aberrational; interest convergence; the historical context of racism; and, narratives, the unique voices of color (Delgado & Stefancic, 2001). The presence of CRT was important to the study because it brought forth a full analysis and provided a mechanism to discuss the use of power as it affects race and racism in this academic environment, consisting of the classroom, engineering departments, labs and study halls. CRT accounted for the women's experiences allowing for critical examination through a lens focused on inherent challenges centered on the race.

The research questions to be answered were:

1. How do successful African American women in engineering experience and make meaning of their academic environment?
2. How do successful African American women in engineering respond to their experiences in the academic environment to further their persistence?
3. How do successful African American women make meaning of their relationship with faculty and peers?

During this study, I found these women made meaning of their academic environment by trying to understand it, utilize it and in some cases overcome it. They

worked to comprehend their surroundings by building relationships with other students, faculty and administrators, and learned from these interactions and connections. These women learned to recognize when building a relationship with another student, faculty or administrator was not an option. In these instances, they obtained skills to maneuver around and sometimes, through obstacles. The women in the study responded to their experiences by setting goals and developing plans to reach or explore their goals. All of the women determined the path they wanted to venture on after graduation. Some of the directions were more focused than others, but they all had a path and they were all scheduled to graduate with an engineering degree.

I discovered that the women in the study persisted by using many resources at their disposal on their respective campuses. These resources took on the form of faculty office hours, tutoring sessions, study sessions with peers, internships, relationships with graduate students and active participation in a counterspace, NSBE. To further their persistence the women worked hard, studied, practiced and completed homework assignments both alone and with peers. Finally, they had goals that motivated them to persist when the academic or environmental challenges increased. With this notion, I ascertained these women to be intrinsically and/or extrinsically motivated as they developed and with this motivation came the use of academic achievement goals.

The women also discussed the existence of racism and sexism in their varying academic environments. All of the women were aware of these obstacles and many of

them made the decision not to let challenges of race and gender affect them and the goals they set for themselves.

Finally, the women in the study made meaning of their relationships with faculty members and their peers by realizing the importance of both groups, especially faculty. They arrived at this conclusion when they realized that faculty members are the gatekeeper to their education. The faculty members provided them access to information needed to persist as well as access to research, educational and career related opportunities. These relationships were crucial to their success. In reference to their peers, the women concluded that these relationships contributed to their academic success as well. Their peers were available to share information and knowledge, complete project work, study collectively and provide moral and academic support.

Discussion

The meaning of the study both corroborate and build upon previous research, using the participants' voices to reveal the manner in which they experienced their academic environment as African American women. Within these experiences, five finding emerged. The findings of this study focused on: the women and their self-efficacy which allowed for the development of science identities and achievement goal strategies; the motivation they obtained throughout their educational journey; their understanding of

positive faculty and student interaction; support received or needed from institutional agents and counterspaces and systemic racism and sexism.

The sixteen women who participated in this study persisting through their undergraduate engineering major towards degree completion continued to succeed through their ability to use resources available to them. Over time, these women learned to navigate their respective engineering schools and used this knowledge to their advantage as well as for others. Some of the women were challenged more than others, due to the systemic racism and sexism they faced. Some others had to fight off negative self-talk that questions their ability while others did not have these types of conversations with themselves.

Self-Efficacy

All of the women experienced or witnessed racism and social stigmas in their academic environment, and they navigated this atmosphere differently. Most of the women recognized the micro-aggressions and stereotype threats waged against them by some faculty members and/or their White peers. Some women were more susceptible to this chilly climate, but were able to sustain their academic status, even if they were not happy in the environment. However, self-efficacy emerged as one of the traits these women possessed. More specifically and concurring with research findings from MacPhee, Farro and Canetto (2013), these women demonstrated academic self-efficacy

because most of them retained the confidence in their own academic abilities to complete academic assignments as well as influence their educational and career interests and expectations. In some instances, negative stereotypes diminished self-assessments of academic abilities ultimately jeopardizing educational and career related ambitions (Hill, Corbett, & St Rose, 2010).

Regardless of the challenges, these women possessed a strong academic self-efficacy allowing them to focus on their academic achievement goals, undeterred. All of the women had goals of successfully completing their undergraduate engineering degree and as this goal was realized, the next goal was set. All of the other women in the study had goals to complete their undergraduate engineering degrees. Once this goal was completed, they all had additional goals to branch off into the medical field, graduate school and/or the workforce. Brandy was the one woman in the study who exhibited work avoidance tendencies, but despite all of her challenges she persisted. She will graduate with a chemical engineering degree; however, she does not want to pursue an engineering career.

These women incorporated intellectual and emotional elements of behavior that were goal driven (Ames & Archer, 1988: Dweck, 1986; Dweck & Elliott, 1988; Dweck & Leggett, 1988). They incorporated self-efficacy and a good academic work ethic that produced behaviors created by their beliefs about themselves, the acknowledgements

about their environment and academic results that developed into the intended outcomes (Weiner, 1986).

In conjunction with their academic achievement goals, these women developed science identities. They were competent and able to demonstrate significant knowledge and understanding of science content learned. They were also recognized by faculty, peers and employers for their science knowledge. The recognition of these women's science identities is significant because the science identity focus provided a robust examination of race and gender and the manner in which these two factors influence the science identity of African American women in engineering majors. The science identity construct also enabled me to determine how these women viewed engineering through the skills, knowledge and experiences they attained. These women viewed their engineering abilities as assets they would use to become researchers, engineers, medical professional or to fulfill other interests. Their science identities also demonstrated their belief in the worth of their engineering degree pursuit (Cobb, 2004). Moreover, science identity is dynamic and this framework enabled me to determine that these women's science identities developed as the women persisted, gained confidence and solidified their career goals, concurring with the notion that identity is not static and over time a science identity can be cultivated throughout various contexts (Brown, Reveles & Kelly, 2005; Gee, 2000; Lemke, 2001).

Motivation

The women in the study were highly intrinsically motivated. Intrinsic motivation is defined as "the doing of an activity for its inherent satisfactions rather than for some separable consequence" (Ryan & Deci, 2000 p. 56). With the use of intrinsic motivation, the women were encouraged to engage in an activity for the fun and/or challenge rather than because of external rewards, pressure or stimulation. The use of intrinsic motivation became apparent in conversations with most of the African American women interviewed. In contrast to intrinsic motivation, extrinsic motivation is defined as performing an activity to attain an independent outcome as opposed to an inherent satisfaction and a smaller representation of the women felt they were motivated extrinsically. Regardless of the type of motivation, each woman in the study was driven, for various reasons, to succeed and this drive culminated into their academic achievement goals before and after graduation.

Weiner (1972) posits that achievement theory is a cognitive theory that "assumes that one's beliefs about the likelihood of attaining a goal (success at an achievement task) mediate between the perception of the task stimulus and the final achievement-related response" (p. 169). All but one of the women in the study persisted toward degree completion as they utilized one of two or both motivational constructs of achievement goal theory: performance goal or mastery goal strategy. They select a performance goal strategy because they were motivated by and inclined to exceed academic standards and

outperform their peers in order to defy stereotypes and/or to prepare for graduate programs. Aiming for and attaining this goal enabled the women to increase their self-worth (Covington, 1984; Dweck, 1986; Nicholls, 1984) and potentially secure their science identity (Carlone & Johnson, 2007). Some of the other women were more inclined to employ mastery goal strategies which provided them with a focus on the process of mastering the subject matter and developing new skills, thus improving the level of competence (Brophy, 1983; Meece et al., 1988; Nicholls, 1989).

Moreover, underrepresented populations, such as African American women in engineering, may encounter obstacles due to negative messaging including stereotype threat (Steele, 1997), microaggressions (Solórzano, Ceja & Yosso, 2000) and a chilly climate (Morris & Daniel, 2008). In these instances, the unwelcoming environment could lead students to implement an avoidance strategy which could deter them from persisting and ultimately from degree completion. The work avoidance goal strategy motivates the student to exert minimal effort (Brophy, 1983; Duda & Nicholls, 1992), which in turn has a negative effect on motivation and performance (Archer, 1994; Meece et al, 1988; Nicholls, Patashnick & Nolen, 1985; Nolen, 1988). Brandy employed this strategy, but she vowed to persist to degree completion and was a senior persisting to degree completion at the time of this study.

Achievement goal theory integrates cognitive and affective elements of behaviors that are goal driven (Ames & Archer, 1988: Dweck, 1986; Dweck & Elliott, 1988;

Dweck & Leggett, 1988) bringing forth behaviors by incorporating a collection of beliefs, acknowledgments and results that construct the objective of these behaviors (Weiner, 1986). These varying behaviors constitute different methods of advancing, participating in and reacting to activities related to achievement (Ames, 1992b; Dweck et al., 1988). According to Dweck et al., (1988), achievement goals are defined as involving a "program" of cognitive process that has "cognitive, affective and behavioral consequences" (p. 11). These women participated in academic activities that were fulfilling and rewarding and provided them academic benefits. (Brophy, 1988; Glynn, Aultman, & Owens, 2005).

Faculty Interaction

The study brought to bear the importance of faculty members and their interactions with African American women in engineering. Not all of the interactions were positive; however, my study concurs with prior research suggesting faculty and student interactions will impact student learning and personal development (Cruce, Wolniak, Seifert, & Pascarella, 2006; Kuh & Hu, 2001; Pascarella & Terenzini, 1991, 2005; Tierney, Corwin, & Coylar, 2005) for students of color like African American students (Lundberg and Schreiner, 2004).

As demonstrated by the narratives, most of the women had positive and productive relationships with their faculty; however, it became apparent that the women

initiated the connections and were responsible for maintaining them. This study confirms previous research suggesting that support from, and interactions with faculty are significant dynamics that contribute to the success of underrepresented women in STEM majors regardless of the individual who initiates the relationship (Griffin, Perez, Holmes, & Mayo, 2010; Rendon, 1985; Seymour & Hewitt, 1997).

The women interviewed understood this significance and determined that faculty members could affect them in either positive or negative manners. The women recognized faculty members to be keepers of information, grades, research opportunities and networking contacts and students need these items to succeed. Moreover, developing a positive relationship with faculty members increased the chances of having access to these items as well as information. Some of the narratives emphasize the point that students needed to show-up and develop relationships with faculty, allowing them to take advantage of the faculty, as a resource. Even though they all understood this fact, some of the women confessed to not utilizing this resource as well as they could have.

The African American women in this study highlighted the importance of developing and nurturing relationships with faculty within a caring environment. These women actively sought out professors, particularly professors who supported them and their academic success in a respectful and caring manner. Faculty members who were inclined to be condescending and mean were avoided as much as possible.

An outcome of this finding is the realization that the women were responsible for developing and nurturing these faculty relationships. This outcome requires further investigation within implications of the policy and practice section of this chapter due to the significance of this relationship between faculty and students.

Student Interaction

Most of the student interactions in class with academic peers were a means to an end because these relationships were developed out of necessity for studying and group work. The women understood that it would be difficult to thrive in an engineering program without interaction with their academic peers. Some of the women did not consider many of students in their classes to be friends because they did not experience a sense of belonging with these academic peers. However, there were other women who did develop friendships with small group of students in their classes. These students served as study partners as well as social friends. These women were more fortunate because they had friends who were also in their major or classes.

All of the women in the study concluded that they could not succeed in engineering without their peers, White, Black or otherwise. Granted, some of the preferences were to study and work alone, but the women realized the importance of their academic peers. This study's conclusion is in agreement with research stating the

following: as the women work with other students, the interactions allowed them to develop relationships within the environment they shared (Kuh, 1991; Zhao, Kuh, & Carini, 2005). Additionally, the women recognized that their friends, whether in NSBE or not, were their emotional peer support mechanism.

Institutional Agents and Counterspaces

The study also highlighted the importance of other institutional agents, besides faculty, on campus who had power, status and control over resources at the varying institutions. These individuals used their position to provide access to resources and associated opportunities (Stanton-Salazar, 2011). During this study, institutional agents included engineering college deans, teacher assistants, and graduate students as well as faculty. These institutional agents were supportive and were willing to share resources. According to research conducted by Bensimon & Dowd, 2012; Chase, Bensimon, Shieh, Jones, & Dowd, 2013), an important role of institutional agents is to help students maneuver around institutional bureaucracies and provide students with information about college cultural and associated expectations. Institutional agents are also instrumental in providing access to educational resources and emotional support.

The findings of this study are consistent with these sentiments because it became apparent that deans and advisors at the institutions were active advocates and institutional agents for the African American women in the study. These institutional agents were

individuals in the academic environment who provided a safe and manageable atmosphere within the college experience where students were socialized into the community while they explored their various identities on campus (Harper & Quaye, 2007; Murguía, Padilla, & Pavel, 1991; Museus, 2008; Padilla, Trevino, Gonzalez, & Trevino, 1997).

In conjunction with support from institutional agents, counterspaces provide positive support and should be categorized as an important factor in the success of students of color (Harper & Quaye, 2007; Museus, 2008). A substantive example of a counterspace is the National Society of Black Engineers. Their mission is "to increase the number of culturally responsible Black engineers who excel academically, succeed professionally and positively impact the community" (NSBE Website, 2016). The majority of the women interviewed discussed their active participation in NSBE. Some of the women held leadership positions, like Jasmine, Jordan, Brandy and Kelly. The remaining women attended NSBE conferences and/or were active in NSBE activities such as community service initiatives and tutoring sessions both giving and receiving.

The presence of NSBE was important to these women because it served as a place to see familiar faces and where individuals were able to ask for, receive and provide support. With the support of counterspaces, the women developed a voice that could be heard on campus, which in turn provided administrators with additional information that could improve upon existing institutional practices (Kuh & Love, 2000; Museus &

Quaye, 2009). This was evident, in particular, with the women who held leadership roles within the NSBE organization.

Systemic Racism and Sexism

Another finding was the presence of racism and sexism. All of the women recognized racist behaviors. Some of them experienced racism first hand while others witnessed it. Many of the women had the luxury of ignoring racism, not letting it deter them from their goal; however, because it was ordinary, some of the women admitted to being used to it. Some of the women mentioned the effects racism had on them in the classroom and how they had to combat the feelings of being less than. One CRT tenet describes racism as being ordinary and not aberrational (Delgado & Stefancic, 2001, p. 7) and this acceptance is the "realist view" acknowledging the significant role racism controls and continues to control in society (Bell, 1995; Lawrence, 1995). This realistic view is expressed in the narratives as the women mention they were used to being the only one or they were used to feeling left out. However, being used to racist and sexist conditions that are detrimental is not healthy; thus these academic environments require transformation.

The women did not express as many instances relating to sexism; however, it still existed and women had to manage these deterrents as well. According to research conducted by Nosek, Banaji and Greenwald (2002), stereotypical bias does exist when women are considered in the STEM environment. Some of the women narrators in the

study encountered microagressions and stereotype threat due to their gender and the academic environment containing primarily White men (Solórzano, Ceja and Yosso, 2000; Sosnowski, 2002). Moreover, this study concurs with Johnson (2007) suggesting that negative socialization in STEM environments cause women of color to feel insignificant when individual characteristics like race and gender are deemed irrelevant to the teaching and learning.

As these findings are further examined, two conclusions surface; first, findings in this study directly relate to and corroborate with study findings focused on the broader higher education or STEM environments regarding: (1) the chilly and unwelcoming STEM academic environment (Brand, Glasson, and Green, 2006; Carlone & Johnson, 2007; Hanson, 1996, 2004; Justin-Johnson, 2004; Ong, 2005); (2) the importance of institutional agents (Bensimon & Dowd, 2012; Chase, Bensimon, Shieh, Jones, & Dowd, 2013); (3) the importance of positive faculty to student interactions (Kuh et al., 1990; Lundberg and Schreiner, 2004) and positive student to student interactions (Whitt, Edison, Pascarella, and Terenzini, 1999)

Second, the study's significance and meaning emphasize the importance of a comprehensive approach as these interconnected findings are developed and executed together as a unit. These findings and their associated actions can assist African American women when used separately; however, this approach would not manage the students' needs completely. All of these finding areas are required to develop and

implement a systemic, transformative and sustainable plan that is purposeful in its aim to support African American women in engineering to persist to degree completion.

Implications for Policy and Practice

Findings from this investigatory study have several implications for the policies and practices at institutions and in engineering colleges. While the findings were presented separately, it is important to note that the findings and their associated policies and practices are interrelated and should be viewed as a holistic process that requires all elements to support African American women as they persist to degree completion. These support elements, despite the racism and sexism encountered, enabled the women to persist toward degree completion with motivation and academic achievement goals. With this notion, institutions and engineering departments must develop and implement policies and practices that incorporate this holistic process and at the same time, eliminate racism and sexism within the school and engineering department. This action will "influence the retention, persistence and achievement of underrepresented minority women in STEM fields" (Malcom & Feder, 2016, p. 3-22).

If undergraduate engineering environments are to be viewed as communities of practice (Lave & Wenger, 1991; Wenger, 1998), whereby ambitious individuals must engaged in an environment of shared learning, it is important that faculty and college administrators understand how African American women associate with, become isolated

from and/or negotiate the cultural norms throughout their academic communities. This knowledge would assist faculty and administrators as they develop environments that are supportive of and welcoming to African American women in engineering. With this notion, the sense of belonging for African American woman in engineering requires improvement. Engineering colleges within institutions must acknowledge and correct the lack of a sense of belonging as they consider the experiences of underrepresented students in engineering, like African American women. Engineering colleges can acknowledge and examine the lack of sense of belonging by creating purposeful focus groups with current students and graduates. The data from the focus groups should be analyzed and used to create systemic strategies focused on improving the sense of belonging. This strategy would encompass the development and implementation of faculty development, programs, pedagogy, curriculum and initiatives that promote positive faculty interaction (Griffin, Perez, Holmes, & Mayo, 2010; Rendon, 1985; Seymour & Hewitt, 1997) and classroom diversity and inclusion (Gurin, P., Dey, Hurtado, & Gurin, G., 2002) in such a manner that African American women will have a sense of belonging within the college of engineering environment.

Faculty members should actively participate in periodic development workshops that will equip them with tools to interact with and engage underrepresented students in a manner that improves the students' sense of belonging and sense of community as well as conduct more open and honest dialog amongst students. This development should include

a hidden bias exercise, enabling the faculty and institutional agents to understand their racial biases, how these biases affect students and how to address them.

Second, faculty members play an important role as facilitators of the classroom and in managing difficult situations or dialogues related to race and gender. Thus, the faculty members need the required knowledge and skill-set to facilitate these conversations with students who have varying degrees of comfort with these types of discussions focused on race and gender (Quaye, 2012). To manage these difficult dialogues, faculty members require sufficient preparation (Beale, Thompson, & Chesler, 2001; Zúñiga, Nagda, Chesler, & Cytron-Walker, 2007), the ability to focus on students' comfort levels when the focus is on racial differences (Roberson, Kulik, & Pepper, 2002), and the skills to facilitate these dialogues with learners who have varying experiences with dialogs relating to race (Garcia & Van Soest, 2000; Roberson et al., 2002). Faculty members should also participate in workshops that enable them to develop and present a curriculum that is diverse, culturally responsive and represents relevant real-world challenges.

Additional policy and process development specific to an institution or engineering department should be determined, developed and implemented whereby faculty play an instrumental role. The engineering college institutional agents along with student affairs are also needed to create policies and procedures as well as participate in the development workshops.

Best practices pertaining to educating a diverse student body should also be reviewed to determine if relevant material can be used. It would be important for this initiative to become systemic and not be created in a vacuum. Within the creation of the systemic strategy, faculty members should work as a team to develop strategies and curricula that could foster a better sense of belonging for African American women in engineering. Finally, the institution should be committed to this effort and show its commitment, by supplying the necessary resources, enabling the initiative to be transformative and sustainable.

This transformed academic environment should also take into consideration the fact that African American women, along with their successes and failures, do not represent the entire African American population and the students should not be expected to bear this weight on their shoulders. This new environment would be one where African American women are not constantly questioning their academic aptitude and their place in the classroom, and are not intimidated by faculty members.

African American women in engineering work hard, sacrifice, are motivated and have plans as to their next goal. However, these women should not have to compensate for their gender and/or race in an academic environment. They should understand the engineering curriculum will be challenging, but they should be able to use their race and gender in the class to contribute their ways of knowing into discussions and not have it used as a negative characteristic they cannot escape. With this notion, colleges of

engineering should require faculty to develop curriculum that encompasses diverse discourse of opinion, enabling the entire class population to learn in a safe environment, through a more robust dialogue.

The significance of a positive student-to-faculty interaction factor directly relates to the success of African American women in engineering. With this notion, it is essential that colleges of engineering use this concept to develop, implement and monitor initiatives that provide more purposeful and positive student-to-faculty collaboration. These collaborations could take on the form of mentoring or research work as examples. This interaction could help to break down stereotypes and foster better relationships with faculty members and African American women as well as create an environment where students could develop more confidence in their abilities. The positive interactions could also reduce the chilly climate phenomenon experienced by some African American women within the STEM field.

It is important for engineering departments to consider a more racially and gender friendly environment. This transformation should encompass the culture by examining and shifting the cultural competence of the department and the curriculum whereby the departmental culture and curriculum are reimagined and developed to be more inclusive in the way it treats African American women and all students. Cultural competence is an important factor for college administrators to consider in this transformation. According to Sue (1998), “cultural competence is the belief that people should not only appreciate

and recognize other cultural groups but also be able to effectively work with them" (p. 440). Being able to effectively work with a diverse population, like African American women, requires the understanding of their diverse perspectives and interpretations. Further, the composition of the faculty and student populations should better reflect racial and gender diversity.

These implications are complex and require transformational initiatives at higher educational institutions. This transformation should affect the pedagogy, curriculum and the composition of the faculty and student populations as well as the beliefs held about underrepresented populations in engineering majors. There are hurdles to overcome; however, transformation is needed to break the traditional engineering college model. Becher (1989) concluded that it would be challenging to alter the culture of a department or college discipline within an institution. He stated "any systematic questioning of the accepted disciplinary ideology will be seen as heresy and may be punished by expulsion" (p. 37). However, if higher education wants to be more inclusive and provide a socially just environment, then engineering college leaders need to commit to diversifying engineering programs, be willing to transform programs and curricula and be willing to commit to the successful persistence of underrepresented groups such as African American women by providing an environment that will value them, their gender and race.

Future Research

From this research study, five topics for future research emerged focused on CRT, science identity, the importance of institutional agents and counterspaces, the relevance of the intersectionality of racism and sexism, and the use of this study's finding for a broader underrepresented population. Weidman's socialization model informed my study by providing a useful framework that enabled me to examine factors that indirectly and directly impacted the experiences of the African American women narrators in the study and shaped their goals to study engineering. I wanted to use the model to better understand the women; how they were socialized prior to college and the experiences that led them to college and to engineering. This undergraduate socialization model provided the reference points allowing me to examine the women and who they were and are.

However, the undergraduate socialization model did not take race, gender or the intersectionality of the two into consideration and these were important factors that directly impacted the African American women narrators. This is the reason CRT was used as an overarching lens for the conceptual framework. My study tells us that the CRT framework was an important element to the overall conceptual framework because it purposefully focused on race, racism and the intersectionality of race and gender whereas the undergraduate socialization model did not. My study also informs me that the use of CRT was and is important when racial minorities are the focus of the study. CRT was an affective framework for my study because it operated in concert with the undergraduate

socialization model enabling me to obtain information about these African American women in a holistic manner. Finally, the CRT framework informed me as to its importance in future research focused on African American women or men in engineering.

CRT suggests that the topic of race should be the focal point when researchers are examining institutional practices and policies that are racist (DeCuir & Dixson, 2004). With this notion, it would be important to use CRT in the conceptual framework and analysis when examining African American students and their experiences. CRT was useful in this study because it provided a manner in which to examine race, racism and power in an undergraduate engineering environment and it enabled the narrative voices to be heard. Continuing in the frame of reference, more research focused on women in specific racial and ethnic groups within the Black population would provide a better understanding of their nuances and similarities. The CRT framework is required for such future research, as it provides a lens which is employed to study the use of power as it pertains to race and racism (Delgado & Stefancic, 2001) and will provide "a contextual analysis of educational policies and practices" (Solórzano, Villapando & Osegueta, 2005, p. 289). CRT will aid researchers in obtaining rich narratives of study participants enabling them to better understand the participants and their lived experiences. The use of CRT will also enable researchers to investigate engineering colleges, through the experiences of the study participants, to determine how the obstacles stemming from race

and racism within the environment affect the students. This information could develop into ways in which to improve upon these experiences that challenge persistence.

This research investigation can be used in conjunction with existing empirical research literature focused on science identity and its importance to the success of underrepresented engineering students like African American women; however, further research is required. A second topic for future research centers on the science identities of African American women in engineering. More specifically, future researchers should examine the manner in which African American students navigate the disciplinary norms and culture of an engineering academic environment to then develop a science identity.

The third topic for future research is focused on the relevance of racism, sexism and the double-bind of their intersectionality. Is the double-bind significant in the experiences of African American women in engineering? To research this question, a study comparing the experiences of African American women and African American men in engineering would be instrumental in determining if gender is still a salient factor in the experience of African American women in engineering. Another important aspect of this future research topic is the question focusing on African American women in engineering who persist to degree completion. With all they encounter, how do these African American women persevere to degree completion in spite of the racism and/or sexism and unwelcoming and chilly climate?

The fourth future research topic focuses on the importance of institutional agents and counterspaces, which was evident in this study as illustrated by institutional agents such as deans, faculty, graduate students and peers and counterspaces like NSBE. Further investigation pertaining to these agents and counterspaces with their associated positive impacts could shed light on their importance and as well as methods by which institutions could help to develop and cultivate them.

Finally, future research should focus on the findings from this study and ask questions to determine if these findings could be used by a larger underrepresented population, thus improving the experience and persistence of a larger group of students who are underrepresented currently. All of these investigatory paths will shed light on the experiences of African American women in engineering and the manners in which higher educational institutions and their associated colleges of engineering could better support this population as they persist to degree completion.

Conclusion

Meeting these women and listening to their narratives, including their victories as well as their struggle and pain, forced me to reflect on my experience as an African American woman in engineering. While listening to the women and their narratives, I have come to understand that while improvements in the engineering academic environment have been made, there are still African American women who feel as though

they do not belong in the engineering academic environment and that they are not academically capable. Despite evidence that they do belong and are academically capable, these women still are affected by these negative messages. One might think if an individual does not fit in the engineering academic environment, then why would their experience change in the engineering workplace? However, these women who participated in the study persevered, persisted and will graduate to transition to graduate school opportunities and careers, mostly in STEM and more specifically, engineering fields.

The most significant observation of this study is the recognition that these women possess self-efficacy. They persevered through all the challenges, whether related to their academics, social interactions with peers, faculty, internship employers, and/or negative self-talk, and with all of this, they have long-term goals that will utilize their undergraduate engineering degrees. As I had the opportunity to meet and get to know these women as they made meaning of their academic experiences, I came to understand that, against all odds, big or small, related to health or academic preparation, faculty or peer challenges, these women will overcome, succeed, graduate and continue to work towards contributing to the larger community.

Finally, as I reflect on the narratives of these women I have concluded that institutions of higher education need to be more supportive of these women through a transformation of policy, practice and curriculum. These women were accepted into

varying engineering programs because they possessed the academic aptitude to persist; therefore, institutions need to provide the environment and support to enable these students and all students to thrive and persist.

APPENDICES

APPENDIX A

INTRODUCTION SCRIPT – FACULTY AND ADMINISTRATORS

University of Massachusetts Boston
College of Education and Human Development
100 Morrissey Boulevard
Boston, MA. 02125-3393

Text and Script for Introduction of Research Study for Faculty and Administrators

Hello my name is Ellise LaMotte and I am a doctoral student at the University of Massachusetts Boston in the College of Education and Human Development, studying higher education with a specific interest in engineering education. I am conducting a research study for my dissertation on the experiences of successful African American women in engineering and I would like your assistance.

I would like you to introduce me and my study to African American women in engineering who you may know and who may be interested in volunteering to participate in the study. If there are women who you recommend, please inform them of the study and send me their email address once you have obtained their permission to do so. I will

contact them through email and introduce myself and the study to determine if they are interested in volunteering to participate in the study.

Thank you for your consideration and assistance.

Sincerely,

Ellise LaMotte

APPENDIX B

TEXT AND SCRIPT FOR STUDENT PARTICIPANTS

University of Massachusetts Boston
College of Education and Human Development
100 Morrissey Boulevard
Boston, MA. 02125-3393

Text and Script for Student Participation Recruitment

This text/script will be employed to recruit student participants via email or telephone.

Dear (email) or Hello (telephone),

My name is Ellise LaMotte and I am a doctoral student at the University of Massachusetts Boston in the College of Education and Human Development, with a specific interest in engineering education. I am conducting a research study and writing my dissertation on African American Women in Engineering.

More specifically, I am conducting the study on the experiences of successful African American women in engineering and I would like your assistance. I would like to interview you to obtain information focusing on your experiences as a student studying engineering. The 1 to1.5 hour interview would take place in a mutually convenient and private location. I would also like to observe one of your classes. Additionally, you may be contacted to participate in a follow-up interview (up to 1 hour) and to review a study findings draft to confirm themes identified from your interview. If you choose to participate in the study and fit the criteria you will be given a $25.00 gift card for your time.

The criteria to participate in the study includes: Identifying as an African American woman whose college major is engineering. The student must also be in her junior or senior year.

If you would like to participate in the study, the information you share will be kept confidential and your name and any other personally identifying information will not be associated with your comments or perceptions. Also, please be assured that participation in this study is completely voluntary and your decision to participate or not participate will have no effect on your relationship with your school.

You have the right to ask questions about this research at any time during the study. You can reach the Principal Investigator, Ellise LaMotte at 617 694-3959 or elamotte8@comcast.net or you can contact her faculty advisor, Tara Parker, PhD at 617 287-7728 or tara.parker@umb.edu.

I truly appreciate your considering this request to participate in this study. Thank you.

Ellise M. LaMotte

APPENDIX C

ELIGIBILITY CRITERIA PROTOCOL

University of Massachusetts Boston

College of Education and Human Development

100 Morrissey Boulevard

Boston, MA. 02125-3393

Eligibility Criteria Protocol

Hello my name is Ellise LaMotte and I am a doctoral student at the University of Massachusetts Boston in the College of Education and Human Development, studying higher education with a specific interest in engineering education. I am conducting a study and writing my dissertation on the experiences of successful African American women in engineering. Thank you in advance for your interest in volunteering to participate in this study.

There are three criteria questions I would like to review with you that will determine if you are eligible to participate in the study.

1. Do you identify as an African American woman?
2. Are you an engineering major?
3. Are you a junior or senior on track to graduate on time as defined by your institution?

If yes to all questions…….

Thank you for your time, you are eligible to participate in the study are you still interested? If yes then, let's schedule a time for the one to one and a half hour interview. I look forward to talking with you about your experiences in an undergraduate engineering program. If no, thank you for your time and I wish you continued success.

If no to any of the questions…….

Thank you for your time, unfortunately you are not eligible to participate in the study but I want to sincerely thank you for taking the time to talk with me and I wish you continued success.

APPENDIX D

GENERIC CONSENT FORM

University of Massachusetts Boston
College of Education and Human Development
100 Morrissey Boulevard
Boston, MA. 02125-3393

UMASS BOSTON INSTITUTIONAL REVIEW BOARD

GENERIC CONSENT FORM for Student Participants

Consent Form For: Unpacking the Individual Experiences and Institutional Factors Shaping Persistence towards Degree Completion for African American Women in Engineering Majors

Introduction and Contact Information

You are being asked to take part in a research project that explores the experiences of African American women in engineering as they persist to degree completion. The

researcher is Ellise M. LaMotte, PhD candidate in the College of Education and Human Development at the University of Massachusetts Boston. Please read this form and feel free to ask questions. If you have further questions later, Ellise LaMotte will discuss them with you. Her telephone number is 617-694-3959 and her email address is elamotte8@comcast.net. Her academic advisor is Tara Parker, PhD and she can be reached at 617 287-7728 or tara.parker@umb.edu.

Description of the Project:

The purpose of this research study is to examine the experiences of successful African American women in engineering in the academic environment. Participation in the study will involve a 1.5 hour in person interview, a class observation, a second in person interview if clarification is needed, and a review of a study findings draft to confirm themes identified from your interview(s). If you choose to participate in the study and fit the criteria you will be given a $25.00 gift card for your time. To participate, you must: identify as an African American woman and be an engineering student in your junior or senior year.

Risks or Discomforts:

The primary risk that may be associated with this study is the emergence of negative or distressful feelings. This risk has been minimized, as no questions of a personal sensitive nature will be asked. However, you may speak with the Principal Investigator, Ellise LaMotte, to discuss any distress or other issues related to study participation.

Confidentiality and Anonymity:

This study is designed to be confidential. That is, the information gathered for this project will not be published or presented in a way that would allow anyone to identify you. The audiotapes, transcripts, and all documents will be completely de-identified by person and school. After you complete the interview(s) and class observation there will be no way of linking your identity to the data collected. Only the Principal Investigator and her advisor will have access to raw data. Individual data is not shared with any other student, faculty, or administrator. A code and pseudonym will be assigned to the schools and audio tape transcripts and no personal identifying information will be recorded in the audio transcripts. A separate master list of participant codes will be maintained in a database on a password protected computer in the Principal Investigator's locked office. Interview transcripts will also be maintained in a locked file cabinet in the Principal Investigator's locked office. All information will be stored for five years and then destroyed.

Voluntary Participation:

The decision whether or not to take part in this research study is voluntary. Indeed, you would be making a contribution to the profession and to engineering education by your participation. If you do decide to take part in this study, you may stop participation at any time without consequence. If you wish to stop participation you should tell the Principal Investigator and leave the interview, or contact her via phone or email. Whatever you decide will in no way affect your status as a student or alumnus of your school.

You have the right to ask questions about this research before you sign this form and at any time during the study. You can reach the Principal Investigator, Ellise LaMotte at 617-694-3959 or elamotte8@comcast.net or you can contact her faculty advisor, Tara Parker, PhD at 617 287-7728 or tara.parker@umb.edu. If you have any questions or concerns about your rights as a research participant, please contact a representative of the Institutional Review Board (IRB), at the University of Massachusetts, Boston, which oversees research involving human participants. The Institutional Review Board may be reached at the following address: IRB, Quinn Administration Building-2nd floor Suite 081, University of Massachusetts Boston, 100 Morrissey Boulevard, Boston, MA 02125-3393. You can also contact the Board by telephone or e-mail at (617) 287-5374 or at human.subjects@umb.edu.

Signatures

I HAVE READ THE CONSENT FORM. MY QUESTIONS HAVE BEEN ANSWERED. MY SIGNATURE ON THIS FORM MEANS THAT I CONSENT TO PARTICIPATE IN THIS STUDY INCLUDING AUDIOTAPING OF YOUR INTERVIEW.

_____

Signature of Participant Date

_____

Signature of Researcher Date

_____

Printed Name of Participant

Typed/Printed Name of Researcher Ellise M. Davis

APPENDIX E

CONSENT TO AUDIOTAPE & TRANSCRIBE

University of Massachusetts Boston

Department of Education and Human Development

100 Morrissey Boulevard

Boston, MA. 02125-3393

CONSENT FORM

CONSENT TO AUDIOTAPE & TRANSCRIBE

Consent Form For: Unpacking the Individual Experiences and Institutional Factors Shaping Persistence towards Degree Completion for African American Women in Engineering Majors

Principal Investigator: Ellise M. LaMotte, PhD candidate, University of Massachusetts Boston and Director, Academic Services Olin College of Engineering

This study involves the audio taping of your interview with the researcher. Neither your name nor any other identifying information will be associated with the audiotape or the transcript. Only the research team will be able to listen to the tapes.

Transcripts of your interview may be reproduced in whole or in part for use in presentations or written products that result from this study. Neither your name nor any other identifying information (such as your voice or picture) will be used in presentations or in written products resulting from the study.

Immediately following the interview, you will be given the opportunity to have the tape erased if you wish to withdraw your consent to taping or participation in this study.

By signing this form you are consenting to (INCLUDE ONLY THOSE OPTIONS THAT ARE BEING USED):

- ❑ having your interview taped;
- ❑ having the tape transcribed;
- ❑ use of the written transcript in presentations and written products.

By checking the box in front of each item, you are consenting to participate in that procedure.

This consent for taping is effective until the following date: __September 30th, 2020. On or before that date, the tapes will be destroyed.

Participant's Signature _____

Date_____

APPENDIX F

INTERVIEW PROTOCOL

Unpacking the Individual Experiences and Institutional Factors Shaping Persistence towards Degree Completion for African American Women in Engineering Majors

Date of interview:

Time of interview:

Interviewer:

Interviewee pseudonym name:

Introduction of my study

Hello my name is Ellise LaMotte and I am a doctoral student at the University of Massachusetts-Boston in the school of Education and Human Development, studying higher education with a specific interest in engineering education. I am writing my dissertation on the experiences of successful African American women in engineering and I would like to have you participate in my research. Thank you for your consideration and I look forward to talking with you about your experiences in an undergraduate engineering program.

Interview Questions

1. Age
2. Hometown
3. Major of study
4. Year in college
5. What subjects were you interested in during high school? Why?
6. What type of support did you receive from your family and community? In what ways does this support continue?
7. Why did you select the engineering program at _____College/University?
8. What are your academic achievement goals and what motivates you to reach them?
9. In your academic environment, what factors help and/or hinder your success in engineering? Say more about _____.
10. Do you have friends who study engineering?
    a. How do these friends support you in academic endeavors?
11. Do you have friends in non-engineering majors? If so, what are their majors?
    a. How do these friends support you in academic endeavors?
12. What institutional or department programs exist to assist you with reaching your academic goals?

13. How supportive are the faculty and the engineering department administration? How much do you think they wanted you to succeed when you first entered the program? Have things changed and if so how have they changed? What are the messages now? Have they changed? In what way?
14. How would you describe the culture of the institution and engineering college/department? In what ways is it conducive to your success as an engineering student? How is it not?
15. How would you describe your interaction with faculty members and peers?
16. In what ways do you think your race and gender play into your academic experiences here?
    a. Sub areas of this question - if the interview participant does not bring them up…
    b. Do you think your experiences as an African American woman are different from your White women or men peers?
    c. Do you work in teams? How are team members selected?
    d. What pressure do you feel as an engineering student (if any)?
    e. To what extent do you feel a part of /the engineering community?
    f. How often do you participate in the classroom discussion and why? How is you participation received?
    g. Who do you like to collaborate with and why?

h. How often do you collaborate with others outside the classroom?

i. Do you feel as though you are treated differently due to your race or gender? If so how?

17. After being here for XX years, have you come to see yourself as an engineer? When do you think you began to take on this identity? Have others begun to see you as an engineer? How do you know?

18. What are your plans after graduation? Why?

Thank you for your time and efforts on behalf of my research project. I again would like to assure you that your identity will be kept confidential and your name and any other identifiers will be changed such that your identity is not known.

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