THE CAREER EXPERIENCES OF

AFRICAN AMERICAN FEMALE ENGINEERS

A Dissertation

by

DELORES NICHELLE RICE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2011

Major Subject: Educational and Human Resource Development

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Approved by:

Chair of Committee,	Mary V. Alfred
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ABSTRACT

The Career Experiences of African American Female Engineers. (August 2011)

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Chair of Advisory Committee: Dr. Mary V. Alfred

Women of color, specifically African American women, within science, technology, engineering, and math (STEM) are significantly underrepresented in workplace organizations. However, the majority of the research addressing STEM issues is centered on increasing the pipeline, recruitment, and retention of underrepresented groups in the K-12 and collegiate domain. There is little, if any, literature focused on the career development of African American female engineers holistically. This is a critical missing link in the research which would support efforts to increase diversity in STEM. The purpose of this study was to provide this missing link by examining the career experiences of African American female engineers and exploring their challenges and support systems during their career development.

This qualitative study was guided by the basic interpretive inquiry utilizing a life history approach. There were nine African American female participants in the study who currently work in an engineering field within an engineering industry. Data were obtained using in-depth interviewing where the participants were digitally recorded and the files were transcribed verbatim. The data were analyzed using thematic analysis.

Using an ecological model to ground the study, the findings were categorized as macrosystem (environment) or microsystem (individual) factors. At the environmental level, the women utilized family support, teachers and counselors, university resources, pre-college programs, minority network, mentors, managerial support, and the company structure as systems of support. Conversely, in the macrosystem, the women were challenged by the limited representation, uncaring and unsupportive professors, unwelcoming peer network, lack of diversity in the workplace, and negative experiences due to their age, race, and gender. At an individual level, the participants relied on their self-image, determination, and perseverance to support their efforts in becoming engineers. On the other hand, microsystem challenges included lacking discipline and focus, experiencing difficulty seeking assistance, and adjusting to the program rigor.

Overall, this research adds relevant information to understanding the experiences of African American women on their journey to engineering. In order to get more women of color in the engineering pipeline and continuing into the engineering workplace, the STEM community will need to examine the microsystem and macrosystem elements, as presented and address the pipeline holistically.

DEDICATION

To my mother, Demetra Delores Demerson-Robertson,

everything happens for a reason.

ACKNOWLEDGEMENTS

This journey was made possible by wonderful faculty mentors, family, and friends who continuously blessed me with their support and love. I leaned on their shoulders to complete this voyage and I am truly grateful for their time and energy.

Special thanks to my advisor, Dr. Mary V. Alfred, for guiding and mentoring me during this process. I learned immensely from observing the leadership that you modeled. It was very important for me to have an engineer on my committee and I am grateful that Dr. Felecia Nave agreed to provide the engineering perspective in addition to helping me navigate the engineering community. Dr. M. Carolyn Clark's passion for narrative sparked my interest in narrative and words cannot express my appreciation for learning about this genre from her. In addition to framing epistemology and methodology, Dr. Kathryn McKenzie shared experiences which significantly contributed to my personal and professional development.

During my tenure at Texas A&M University, I was able to work with some amazing researchers and I learned from the best in the field. The first project allowed me to work with Drs. McKenzie, Skrla, and Scheurich. Drs. McKenzie and Skrla gave me the opportunity to serve on my first research grant and the experience was invaluable. Dr. Jim Scheurich provided mentorship, critique, and support, while serving as a coach. I cannot thank you enough for everything that you shared with me, which will help me accomplish my goals. The second project allowed me to work with Dr. Fred Bonner and Dr. Chance Lewis, in addition to Dr. Alfred and Dr. Nave. Thank you

to this team for allowing me to learn from you and sharpen my skills as a researcher. Also, a special thanks to this team for supporting me as a young researcher in STEM. My individual conversations with each of you made a lasting impression on me completing this journey and going after bigger and better.

Additionally, I would like to recognize the faculty in the Department of Educational Administration and Human Resource Development (EHRD) for their commitment to social justice. I am grateful for the opportunity to learn from their research, teaching, and service to the students.

It is not possible to properly acknowledge the contribution from my mom, dad, sisters, and extended family. Thanks to my mother for sacrificing and showing me resiliency. You read every poem, essay, and chapter, from elementary school to graduate school and your love provided the push for me to make it through this process. A special thanks to my dad for the calls, emails, concern, and encouraging words. I am grateful to have you in my life. I also have to recognize my sisters for taking care of me and making sure that I was taking care of myself. Also, thanks to my grandparents, aunts, cousins, and other extended family members for their prayers and support during this time.

To my friends on this journey with me, you were the village that kept me grounded. I began this process with Petra Robinson and we successfully completed the plan that we created in August 2007. Thanks for sitting next to me in class and sharing the ups and downs. I cannot imagine what this process would have been like without Merlissa Alfred. You are an unconditional supporter, encourager, and believer; I look

forward to celebrating you. Likewise, I look forward to celebrating Shelah Crear in the very near future. We shared lots of laughter and a few tears but most importantly we share a friendship that I value tremendously.

A special thank you to my friendship circle including Cynthia Williams, Shani Rischer, Joan Domengeaux, Tmitri Owens, Della Tyus, Monica Thompson, LaTonia Amerson, and Kerri Wilkinson. Your calls, emails, text messages, cards in the mail, lunch dates, and gifts kept me encouraged, motivated, focused, and grounded. I needed the study breaks, laughter, and heartfelt words to keep me going.

Of course, this study would not have been possible without the participants. I thank the women for trusting me and for supporting this research by sharing their valuable time and personal stories. I salute them for continuing to represent the few Black women in engineering and striving to increase the number for the next generation.

Lastly, I could not end this section without recognizing my Heavenly Father for his grace and mercy. I am blessed and thankful for His unconditional love and for sending all of these earthly angels to get me through this journey. Without Him, I never would have made it.

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CHAPTER I

INTRODUCTION

> The solution to America's competitiveness problem lies in bringing young underrepresented minorities into STEM careers in dramatically increased numbers. The diversity of background, talent, and thought that they will bring to the sciences and engineering is our only hope of maintaining our country's traditional lead in technological innovation.
>
> Nick Donofrio, Executive Vice President of Innovation and Technology for IBM, NACME/AAAS Roundtable. (NACME, 2008, p.4)

The intellectual capital produced by a country is connected to the innovation and advancements made in science, technology, engineering, and mathematics, commonly referred to as STEM (Jackson, 2010; National Academy of Sciences, 2007; NACME, 2008; Science and Engineering Indicators, 2006). Traditionally, the STEM fields set the benchmarks for assessing and comparing intellectual capital per country (Science and Engineering Indicators, 2006). Specifically, what the US produces and contributes as a country in these fields is the measurement of progress, innovation, and leadership. Historically, the US leads the race in STEM research and advancements (National Academy of Sciences, 2007; Science and Engineering Indicators, 2006). However, due

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This dissertation follows the style of *Adult Education Quarterly*.

to a reduction in the number of STEM research projects, a reduction in the number of students pursuing STEM careers, and a move to international markets for engineering production and manufacturing, to name some of the challenges, the US is dealing with the dilemma of diminishing interests and advancements in STEM (Chubin, May, & Babco, 2005; Jackson, 2010; National Academy of Sciences, 2007; Science and Engineering Indicators, 2006). These challenges impact the production and global stance in a technologically-led global society. To address these challenges, oftentimes the engineering community examines the talent pool and efforts to increase the pipeline for STEM occupations (National Academy of Sciences, 2007; NACME, 2008).

The quandary with the talent pool (which impacts the pipeline) is frequently reduced to logic classically associated with energy efficiency: input equals output. In this case, what results as output (an increase in STEM participation) has to be entered as an input. Therefore, in order to increase the number of professionals in STEM, there has to be an increase in the number of students pursuing STEM. Specifically, the US needs to increase the human capital in the STEM disciplines (National Academy of Sciences, 2007; NACME, 2008). One of the primary factors impacting the STEM pipeline is the lack of students interested in mathematics and science courses at the K-12 education levels (NACME, 2008; Science and Engineering Indicators, 2006), which negatively impacts the number of students majoring in STEM disciplines at the collegiate level and pursuing STEM careers.

There are different complementary perspectives regarding the deficit in the STEM pipeline. One line of thought addresses the quality of education and students in

the K-12 level (National Academy of Sciences, 2007; Russell, 2005). Another line of thought, which is a result of the initial perspective, is the lack of students majoring in STEM fields at the undergraduate collegiate level and the continuing lack of students who continue in STEM fields at the graduate level (e.g. Brainard & Carlin, 1997; Maton & Hrabowski, 2004; Moore, 2006; Science and Engineering Indicators, 2006). According to the Gathering Storm Report, published by the National Academy of Sciences (2007), the US is confronted with the following factors:

> K–12 student preparation in science and mathematics, limited undergraduate interest in science and engineering majors, significant student attrition among science and engineering undergraduate and graduate students, and science and engineering education that in some instances inadequately prepares students to work outside universities. (p. 121)

An additional perspective regarding the pipeline specifically addresses the collegiate domain. According to the Science and Engineering Indicators 2006 report, undergraduate degrees awarded in the engineering field significantly increased in Asia and Europe, while the numbers in the US remained constant. The report stated, "Just under one-third of all U.S. degrees are awarded in S&E [science and engineering]. This statistic has held steady over the years, along with the 19% share of NS&E [natural science and engineering] degrees" (Science and Engineering Indicators 2006: S&T The Global Perspective, ¶27). As long as the US enrollment and graduation numbers remain static, the US is at a threat of losing its leadership role in intellectual capital (National Academy of Sciences, 2007; Science and Engineering Indicators, 2006). In order to

increase the enrollment numbers in STEM disciplines, one traditional area of focus is to target and recruit underrepresented populations, which includes women and people of color.

Although underrepresented populations are targeted for recruitment in STEM disciplines, the enrollment trends for science and engineering specifically do not reflect a racially/ethnically equitable distribution. The National Science Foundation's report on trends in science and engineering noted the following**:**

> Projected changes in the composition of successive U.S. college-age cohorts will present challenges to increasing the number of S&E degrees earned by U.S. citizens. The share of whites is projected to decline from 71% in 1990 to 58% by 2020; historically whites have been more likely than other groups (except Asians) to earn S&E degrees. The share of Asians is projected to increase to 6%. The Hispanic share will nearly double (from 12% to 22%), while the shares of Blacks and other minorities will remain flat, at a combined total of about 15%. (Science and Engineering Indicators 2006: S&E Trends in the United States, 2006, ¶11)

The trends noted in the NSF report are similar to the data reported in the Engineering Workforce Commission (2010) report on undergraduate engineering degrees. The Engineering Workforce Commission noted that African Americans account for less than 5% of the total number of engineering degrees at the undergraduate level. There was a sharp decline for African Americans during the 10 year period between 1996 and 2006. However, from 2006 to 2010, the figure has begun to flatten as the NSF trend suggested.

Native American and Foreign Nationals also noted a decline between 2006 and 2010, while Hispanic Americans and Non-Hispanic Whites showed growth in the number of undergraduate degrees. Table 1 provides the demographic figures for bachelor degrees conferred based on race/ethnicity.

Table 1

Engineering Bachelor Degrees Conferred Based on Race/Ethnicity, 1996, 2006, 2010

	1996	2006	2010	% change 96-06	% change 06-10
Native American	1%	1%	0.48%	0	-52%
African American	9%	5%	4.57%	-44%	-8.6%
Hispanic American	7%	7%	7.61%	0	+8.7%
Foreign National	6%	7%	6.22%	+17%	-11.1%
Asian American	13%	13%	11.54%	0	-11.2%
Non-Hispanic White	64%	67%	69.59%	+5%	+3.7%

The degrees conferred to minorities earned at the master's and doctoral level mirror the distribution (based on percentages) shown for undergraduate degrees, with African Americans accounting for 6.6% of the master's degrees and 2.5% of the doctoral degrees in science and engineering (National Science Foundation/Division of Science Resources Statistics, 2006b, 2006c). Moreover, the Engineering Workforce Commission (2006) noted that the percentage of undergraduate engineering degrees conferred to women continues to decline. The total number of BS degrees was over 20% in 2000 to slightly over 19% in 2006. The figure for bachelor degrees awarded to Black women

declined slightly from 10.8% in 2005 to 10.5% in 2006, of the total degrees awarded to women in science and engineering (National Science Foundation/Division of Science Resources Statistics, 2006a). The number of degrees awarded in engineering provides insight into the number of women potentially considering the engineering workforce.

Securing and maintaining a strong engineering workforce is vital in addressing the future of STEM in the US (National Academy of Sciences, 2007), specifically how the US is positioned in the forefront regarding engineering research and advancements. The underlying assertion is that the US has to increase the number of students pursuing STEM education at each level which correlates into STEM careers, in order to remain competitive with other countries and to continue to be distinguished as a leader in STEM. However, the demand will not be met by the current majority population independently (National Academy of Sciences, 2007, NACME, 2008). At a NACME roundtable, Nick Donofrio, Executive Vice President of Innovation and Technology for IBM, stressed the importance of diversity in the STEM fields in stating, "We are going to run out of talent unless we get more women and underrepresented minorities going to college to study STEM" (as cited in NACME, 2008, p. 4). Nick reinforced, "Other countries are going to outnumber us in graduating engineers, but we need diversity of thought and innovation to stay ahead. We need women and minorities, or we have a bleak future" (p. 4). Increasing gender and racial/ethnic representation in STEM fields, generally and in leadership, is paramount to future success in the US and globally.

Statement of the Problem

As presented, the preponderance of literature and research addressing STEM issues are focused on the pipeline, specifically recruitment and retention of underrepresented groups in the K-12 and collegiate realm (e.g. National Academy of Sciences, 2007). For underrepresented populations (American Indian/Alaska Natives, Blacks, Hispanics, and Pacific Islanders, for example) who manage to successfully navigate the K-12 pipeline and collegiate domains, there are additional challenges encountered in professional workplace organizations.

One of the challenges for underrepresented populations in STEM is being overlooked for job promotions and high level leadership roles. According to the National Science Foundation/ Division of Science Resources Statistics (2006e), underrepresented populations represented 10% of the industry workforce of engineers and scientists and a meager 7% secured positions in upper management. The case is equally disturbing for women in STEM.

For women specifically, there are additional challenges in the nontraditional workplace setting. The literature, using nontraditional and traditional terms, typically identify nontraditional careers as those fields occupied predominantly by men, which includes the STEM disciplines (e.g., Burlew, 1982; Burlew & Johnson, 1992). Women account for only 13.5% of the engineering workforce (including architecture) (U.S. Bureau of Labor Statistics, 2008) and a narrow 8% of the engineering management population (National Science Foundation/Division of Science Resources Statistics, 2006d). The Bureau of Labor Statistics, Report on Women's Earnings in 2008 noted,

> Although women are more likely than men to work in professional and related occupations, they are not as well represented in the higher paying job groups within this broad category. In 2008, only 9 percent of female professionals compared with 45 percent of male professionals were employed in the high-paying computer and engineering fields. (2009a, p. 2)

The data are even more staggering for double minorities, i.e. women of color in engineering.

Women of color, specifically African American women, are significantly underrepresented in engineering workplace organizations. Table 2, presents the National Science Foundation's, racial/ethnic demographic distribution for the number of women employed in engineering functions (Division of Science Resources Statistics, 2006f). African American women represent 6% of the professional engineering workforce. American Indian/Alaska Natives are the only minority group with few women represented in engineering. The majority of women engineers are White; Asian and Hispanic women are the next largest racial/ethnic groups respectively.

Table 2
Women Employed in Engineering, 2006

Race/Ethnicity	Number	Percent
American Indian/Alaska Native	1,000	<1
Black	11,000	6
Hispanic	14,000	7.6
Asian	37,000	20
White	120,000	65.6
All Races/Ethnicities	183,000	100

Although, few women have made entry into engineering and found success into the engineering profession, we have very little information on these women and the factors that contribute to their success in the field. African American women are a valuable population in the engineering workplace; yet as the data suggest, they are considerably underrepresented. Additionally, there is a dearth of research and literature examining the career experiences of African American female engineers. While it has been established that much emphasis is placed on developing students for the engineering pipeline, if the field does not address contributing factors that limit growth in workplace organizations, then the overall goal of increasing the underrepresented populations in the engineering field will not be met. The relationship between the need to increase diversity in STEM careers, specifically for women and people of color, and the need to understand the career experiences of these women serve as the stimulus for examining the career experiences of African American female engineers.

Purpose of the Study

The career experiences of African American female engineers needs to be researched and analyzed in order to understand the totality of the experience that frame this group's participation in STEM careers. While the data points to the underrepresentation of women and people of color alike, this study will focus on African American women to understand the depth of their experiences as a double minority in a male dominated profession. Therefore, the purpose of this study is to examine the career experiences of African American female engineers. Using a qualitative design with a life history approach (Cole & Knowles, 2001), the goal is to understand the experiences that contributed to their entering and remaining in the engineering profession. Another aspect is to explore the personal and structural factors that served as support systems and challenges for their career development in the engineering profession.

Researching African American female engineers provides a significant opportunity to increase the pipeline for women and underrepresented populations in engineering and the other STEM disciplines. The underlying goal is to understand how the participants interest in STEM was nurtured and supported throughout their career, the challenges they encountered along the way, and how they interpret their career experiences in the engineering workplace. An additional goal is to add these voices of African American women as a group (a group historically silenced and marginalized) and specifically African American women engineers (a group minimally recognized or represented in the literature, if at all). The career experiences of women, people of color, and specifically of African American female engineers should be presented, understood,

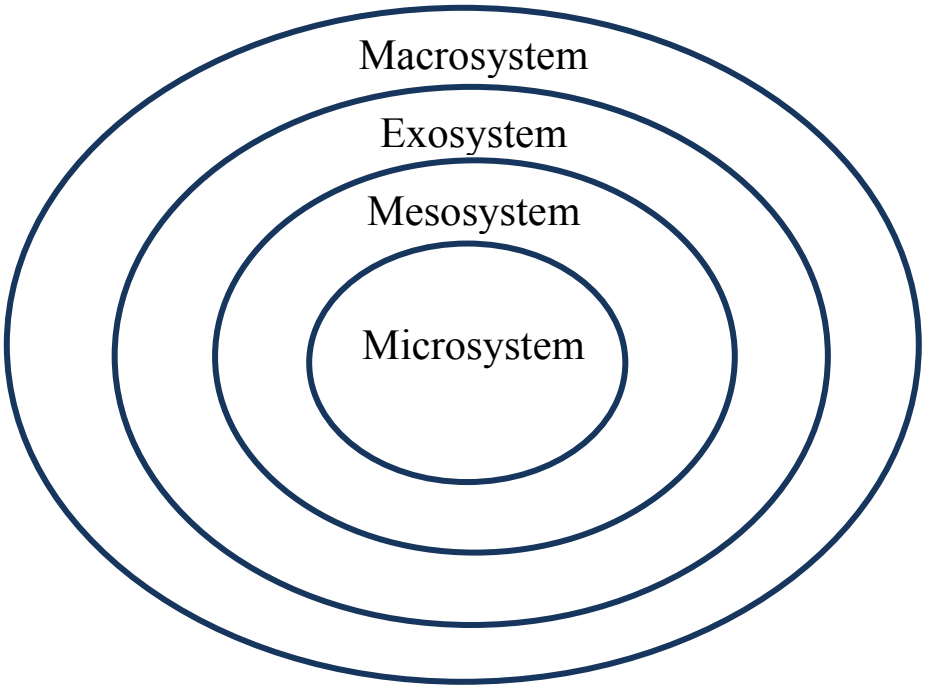
and valued for their experiences, which informs practice to increase the number of women of color and African Americans in STEM.

Theoretical Framework – Ecological Model of Career Development

Cook, Heppner, and O'Brien (2002) propose the ecological model to frame career experiences for all women and especially for women of color because it recognizes gender and racial/ethnic factors in shaping one's life career. The ecological model, as presented by Cook, Heppner, and O'Brien (2002) is grounded in Bronfenbrenner's (1977) work on environmental systems and the dynamic interaction that occurs between the person and environmental systems. Bronfenbrenner identified four environmental systems—macrosystem, exosystem, mesosystem, and the microsystem—as central components in human development. He posited that individual analysis consists of "multiperson systems of interaction not limited to a single setting and must take into account aspects of the environment beyond the immediate situation containing the subject" (p. 514). Therefore, there are factors which contribute to an individual's experience at the individual level and there are factors in the external environment, which influence the individual. Consequently, examining the person's interaction with external environments is a valuable component to understanding the totality of the experience. Figure 1, provides an illustration of the nested relationship between the layers in the model.

Figure 1

Bronfenbrenner's Model of Environmental Systems, 1977



Bronfenbrenner's (1977) model consists of the following four subsystems: microsystem, mesosystem, exosystem, and macrosystem. The microsystem consists of the person's interactions with the environment on a daily or frequent basis, such as school, work, and home. The mesosystem includes interactions and experiences that occur between the person's varied microsystems. The exosystem includes interfaces between the person's immediate environment and an external factor that impacts the person and his/her environment. Lastly, the macrosystem consists of the global society in which the person lives and interacts and the customs imposed on the environment.

Cook, Heppner, and O'Brien (2005) acknowledge the four subsystems in Bronfenbrenner's ecological model; however, they contend that the macro and micro system interactions are most constructive when exploring and framing career development for women of color. The authors purport that interactions in the microsystem are important because, "those individuals or groups with whom an individual woman interacts directly (microsystem) have a dramatic impact on how she views herself and her career choices" (p. 167). Therefore, there is a significant exchange between the individual and her immediate environment and the interactions occur continually throughout her lifetime. Likewise, the macrosystem is equally impactful on a woman's career development due to the global society establishing norms and standards regarding what are acceptable and not acceptable for women of color and their career choice and development. In examining women's careers, Cook et al. (2005) stress that the macro and micro system experiences, due to race/ethnicity and gender, have a direct correlation on career intentions, pursuits, and experiences. They state:

> The larger culture operating as a macrosystem perpetuates career myths and stereotypes related to race and gender and, in fact, institutionalizes forms of race/gender discrimination. This macrosystem embodies such values as White male privilege, Eurocentric worldviews, race-/gender-appropriate ideologies, or race/gender typing of occupational choices. Macrosystem values may be internalized by the individual (e.g. internalized oppression) and, on the microsystem level, influence how others treat a woman because of her gender or ethnicity. (pp. 167-168)

Thus, the ecological model presented by Cook et al. frames this research study by focusing on the interaction between the macro (e.g. stereotypical images, political systems, and the institution) and micro (e.g. self-efficacy, values, and interests) subsystems to examine the career experiences of African American female engineers.

Research Questions

The underlying research question is: *What are the possible factors that significantly influence the career experiences of Black female engineers?* As a result, the following questions address specific factors.

Research question 1: How do the dimensions within the microsystem (individual) influence the career experiences of these African American female engineers?

Research question 2: How do the dimensions within the macrosystem (external environment) influence the career experiences of these African American female engineers?

Definition of Terms

The following terms are used throughout the research study and working definitions are provided for a common reference point:

Career. Using Super's (1976) definition of career as a foundation, career is defined as a sequence of life events, roles, jobs, and positions—including paid and unpaid—that may combine for one targeted area of specialization or many areas of interest during a person's lifetime.

Career development. Career development is "the total constellation of psychological, sociological, educational, physical, economic, and chance factors that combine to influence the nature and significance of work in the total lifespan of any given individual" (National Career Development Association, 2003, p. 1).

Career counseling. Career counseling refers to the relationship between a career counselor and a client to assist the client with career issues such as career transitions, retirement, and career choice.

NACME. National Action Council for Minorities in Engineering

STEM. This is an acronym used in literature and industry when referring to science, technology, engineering, and mathematics disciplines.

Dimensions of Engineering Careers

Engineers use analytical problem solving skills to develop and improve technology. There are different classifications of engineering according to defined areas of expertise, for example: aerospace, agricultural, biomedical, chemical, civil, computer (hardware and software), electrical, electronics, environmental, health and safety, marine, materials, mechanical, mining and geological, nuclear, and petroleum (Bureau of Labor Statistics, 2009b). Engineers serve in different functions within organizations, including new product development, design, manufacturing, and quality assurance, to name a few. According to the Bureau of Labor Statistics, Occupational Outlook Handbook, 2010-11 Edition,

> In addition to their involvement in design and development [for new product development], many engineers work in testing, production, or maintenance.

> These engineers supervise production in factories, determine the causes of a component's failure, and test manufactured products to maintain quality. They also estimate the time and cost required to complete projects. Supervisory engineers are responsible for major components or entire projects. (2009b, ¶3)

The career path for an engineer is varied based on personal interest and career objectives. As stated in the Occupational Outlook Handbook, 2010-11 Edition,

> As new engineers gain knowledge and experience, they are assigned more difficult projects with greater independence to develop designs, solve problems, and make decisions. Engineers may advance to become technical specialists or to supervise a staff or team of engineers and technicians. Some eventually may become engineering managers or enter other managerial or sales jobs. In sales, an engineering background enables them to discuss a product's technical aspects and assist in product planning, installation, and use. (Bureau of Labor Statistics, 2009b, ¶37)

For some engineers, the opportunity to work on the latest technological project is a form of promotion and career advancement. For others, career development includes becoming an expert in a specific engineering niche and obtaining patents for new product development. And yet another identifier of career development success is climbing the ladder from an entry-level individual contributor role to a division managerial role for operations. The engineering career is multifaceted and driven largely by the individual's goals, motivation, and opportunities. Therefore, the participants in the study will have varied perspectives regarding career success and

approaches for their career journey. Each individual path is valuable and provides insight into possible motivators for pursuing and sustaining an engineering career.

Significance of the Study

Adult Education and Human Resource Development programs embrace career development research and literature as a central focus. These programmatic areas value adult learning and experiences holistically and specifically in the workplace. This research complements these fields, particularly by contributing interdisciplinary knowledge that is focused on adult development with a social justice component and professional education emphasis. This research seeks to make a significant contribution to the research, practice, and policy regarding engineering education.

Research

Research and literature addressing the career development of Black women in the workplace are scant, relative to White women whose patterns of work and living are typically generalized to those of Black women (e.g. Phillips & Imhoff, 1997). Moreover, research addressing Black women in engineering is nearly non-existent. Due to the dearth of information on the career development of Black female engineers, information is pulled from a general perspective with regards to women's career development and is often examined according to the dominant group. As a result of limited perspectives, researchers (e.g. Fouad & Byars-Winston, 2005; Thomas & Alderfer, 1989) made a call to include more voices from women of color in career development literature and the proposed research will answer the call.

Practice

This research will contribute to practice in terms of increasing diversity in engineering specifically and STEM overall. This research seeks to inform school teachers and leaders in K-12 education, as to the early childhood educational experiences that had a significant influence on the African American female participants. In order to increase the pipeline for students pursuing STEM careers it must be understood that such experiences go beyond having an interest in mathematics and science as the primary contributors to a career in an engineering profession. Additionally, this research will inform faculty and staff and their leadership in colleges and universities regarding engineering education. The data gained from the participants will include information on engineering pedagogical methods, support systems, and barriers during the undergraduate collegiate experience that serve to recruit and retain this targeted group in engineering. Finally, this research shall inform STEM professionals and their leadership in corporations by providing career development elements that retain and support African American female engineering professionals. Specifically, it is anticipated that this component will include strategies that workplace organizations can adopt to support African American female engineers and other underrepresented groups in STEM to be successful in the engineering industry.

Policy

In addition to its contribution to practice, this research also seeks to impact education policy regarding diversity in STEM. This research will inform education policy in the K-12 domain by contributing information that addresses how we teach

students and how students learn juxtaposed how the knowledge is utilized in industry. There is an opportunity to address pedagogical methods, which would attract African American female engineers and other underrepresented groups to the field of engineering. This information will add value not only to the engineering community holistically but to the education system overall. Similarly, this research seeks to inform education policy in higher education. Additionally, this research will inform policymakers regarding funding for STEM education and support systems, for example tutoring, mentoring, and experiential education programs, that assist African American female engineers in pursuing engineering careers.

The number of women and students of color entering and graduating engineering programs, and then successfully transitioning into STEM professions needs to increase in order for the U.S. to continue to be competitive in engineering and technical disciplines. Research on the career experiences of African American female engineers makes a positive contribution toward establishing gender and race equity and diversity in engineering.

Delimitations of the Study

This study focused on the experiences of 9 African American female engineers working in engineering functions within engineering organizations. The parameters of this sample are narrowly scoped for a deep understanding of how the race/ethnicity and gender factors of career development are specifically framed within the engineering context. The goal is not to generalize the findings to a larger sample size or a different population altogether. Although there are possible similarities between African

American females in other professional contexts, this research is focused on the engineering environment.

Dissertation Format

This dissertation will be written and defended using the journal dissertation format. Two independent manuscripts are included. A brief description of the content is provided below:

Chapter I: Introduction

Chapter II: Provides an integrative literature review addressing the career development of African American women. The literature included focuses on career development historically, research on African American women and African American engineers including empirical and conceptual research conducted on African American females and African American female engineers.

Chapter III: Describes the research design for the study including the participant selection process, data collection, and data analysis. The researcher's positionality and case story are also presented. Additionally, an individual case story for each participant is presented to provide insight into the participant's lives as shared with the researcher.

Chapter IV: Manuscript report of the macrosystem and microsystem challenges addressing the career experiences of African American female engineers based on the findings from the research. The findings will be presented and examined according to the literature, with implications for key engineering education community stakeholders on how to address the challenges, which may positively impact recruitment and retention in the pipeline and the workplace.

Chapter V: Manuscript report of the macrosystem and microsystem support structures adding to the career experiences of African American female engineers based on the findings from the research. The findings will be presented and examined according to the literature, with implications for key engineering education community stakeholders on how to build these systems to positively impact recruitment and retention in the pipeline and the workplace.

Chapter VI: Conclusion of the research findings with implications for workplace organizations, K-12, higher education, and education stakeholders. Suggestions for additional research in engineering education and STEM will be included.

CHAPTER II

REVIEW OF THE LITERATURE

Literature centered on career development provides the groundwork for the research study. This section presents a review of the career development literature in four sections. First, a historical and foundational segment of literature dedicated to traditional career development theory is covered. Second, an overview of the research using the ecological model of career development is added. Third, literature addressing the career development of African American women is included for additional contextual reference. Lastly, research and literature addressing the career experiences of African American female engineers is contributed.

Traditional Career Development Theories

Career development theories inform how career decisions are made, develop over time, and are connected to individual characteristics (Niles & Harris-Bowlsbey, 2009). Oftentimes, the early or traditional theories are characterized into two categories according to the approach taken in addressing career development. The first category, trait-factor is based on individual composition including one's personality, interests, and traits, which would match particular careers. Holland's (1966, 1973) work on personality categories is one of the significant trait-factor theories. Other trait-factor theorists include Dawis and Lofquist (1976) and Brown (2002). The second category focuses on the developmental process and how the person changes over time. Super (1953) and Gottfredson (1981) provided dominant models examining career

development throughout the lifespan. This section presents an overview and critique of Holland (1966, 1973), Super (1953), and Gottfredson's (1981) model of career development.

Trait-Factor Approach

Holland's Career Typology. Holland's (1966) theory of vocational choice is "primarily concerned with explaining how people make vocational choices, what leads them to change jobs or vocation, and what personal and environmental factors are conducive to vocational achievement" (p. 1). In this model, the individual's personality is the primary factor in examining the degree of fit with the individual and the work setting. Therefore, Holland's model is classified as a trait-factor model because the focus is "on describing and measuring individual characteristics rather than organizational variables" (Betz, Fitzgerald, & Hill, 1989, p. 26). There are six categories in Holland's (1966) model which identifies vocational personalities: realistic, investigative, artistic, social, enterprising, and conventional. An individual has a combination of all six categories; however, Holland's model highlights that there are three types which are most aligned with an individual's personality. Betz et al. (1989) noted, "Similarities between the types can also be described in terms of basic dimensions, such as people oriented (social, enterprising) versus non-people-oriented (realistic, investigative) and intellectually oriented (investigative, artistic) versus practically oriented (conventional, realistic)" (p. 33). Using this assessment, Holland posits that individuals in vocations aligned with their personality are typically content

and less likely to change environments, with the opposite occurrence for those not properly matched with their personality.

A review of this theory reveals the absence of sociocultural variables, for example race and gender. Similarly, it has been critiqued for its minimal focus on individual factors (Betz et al., 1989). Moreover, Super and Hall (1978) noted a lack of information correlated to adult changes within the organizational realm. Additionally, one may challenge the view of placing personality congruence as the primary factor in vocational satisfaction. For example, consider the individual whose personality assessment might identify an artistic career in dance or art. However, financial responsibilities will not allow that individual to pursue that career path and, hence, they select an investigative occupation. In this example, Holland's model suggests that the individual who elected to pursue the investigative career path would not be content with the career choice. However, one can speculate that financial reward, from the alternate choice may provide a level of contentment that would make up for the preferred career choice. Therefore, this model is one-sided in assuming that personality alone is directly proportional to workplace satisfaction.

Developmental Approaches

Super's Theory of Vocational Choice. Super's (1953) theory is based on personality and self-concept. His theory is classified as developmental because the skills obtained in the developmental process build from one level to the next. Super's life span model is based on propositions, which are summarized as follows: individuals differ in personalities, abilities, needs, values, interest, traits, and self-concepts; individuals

qualify for multiple occupations based on their background; individual self-concept is impacted by experience and time; and occupational determinants are directly related to familial sociocultural capital. According to Savickas (1997), these propositions served as a blueprint and as a set of guiding principles for examining vocations and counseling for careers.

There are five life stages in Super's (1953) model: growth, exploration, establishment, maintenance, and disengagement. Each stage in the model is associated with an age range and characteristics for what occurs during the stage. The growth stage takes place from early childhood to age 13 and highlights the curiosity and initial interest that children develop as they fantasize, play, and learn about their environment and surroundings. Exploration is the second stage, which occurs from ages 14-24. During this stage, adolescents and young adults begin to investigate career options and understand their preferences for work. The third stage, establishment, is typically identified for ages 25-45. At this point individuals settle in a career and launch a plan for accomplishing their goals. Maintenance is the fourth stage, which describes the individual's position in sustaining their current role or possible changes for the 45 to 65 year old population. The final state, disengagement, occurs around age 65, and focuses on retirement and lifestyle beyond work. The five stages in Super's model note the changes that occur as one evolves throughout the lifespan and possible influences on the individuals career development.

In his 1953 model, Super stressed the importance of self-concept to the individual career development plan. In 1980, he revisited and supported his initial

developmental model and purported that the stages are not directly proportional to the chronological age of the individual and that navigating through a cycle does not imply mastery without re-examination. Niles and Harris-Bowlsbey (2009) concur that the stages are not necessarily linear and that a person can be in different stages concurrently. Although Super's contribution to providing a dynamic model is recognized, the importance of individual and cultural environmental factors has been minimized (Niles & Goodnough, 1996). These elements are critical when considering diverse populations and their career development opportunities. In analyzing the literature, self-concept is one component of a person's identity; thus it should be considered as an element in vocational choice, not the sole source.

Gottfredson's Theory of Circumscription and Compromise. Gottfredson's (1981) model of cognitive maps is classified as a career developmental model. According to her model, individuals develop cognitive maps organized according to the gender perception of the occupation, image or stereotype of the occupation, and interest in the field of work. Gottfredson identifies circumscription as the process where individuals narrow their range of occupations according to the criteria specified and the extent to which it is accessible. Compromises occur when there is an opportunity to obtain an occupation that is easily accessible (Gottfredson).

Taylor and Pryor's (1985) research sought to investigate Gottfredson's (1981) theory of compromise and circumscription. They completed a quantitative study by surveying 287 high school students, with 52% males and 48 females. In lieu of hypotheses, the researchers explored general issues related to compromise and prestige,

gender, primary career choice, and secondary career choice. Their findings support Gottfredson's model, specifically the impact of gender roles, interest, and status in relation to compromise. However, they noted that the ways in which compromises occur are intricate. Moreover, like Super (1953), this model also values self-concept in career choice and alignment. Gottfredson (2002) revisited her model to focus on differences in career development between individuals belonging to the same group. Her goal was to address "powers an individual has, but may not always exercise, to create a public self that resonate[s] better with his or her unique internal self" (p. 86). However, the basic tenets of her revised model remained the same as her initial model.

Leung and Harmon's (1990) critique of Gottfredson's (1981) model notes her focus on early childhood development with regards to self identity and potential career assessments, with minimal attention to development later in the lifespan. The first stage in her model begins at age 3 and the last stage addresses ages 14 and up. In analyzing the model, one notes that the last category in her model does not address the gap from age 14 to adulthood and how those experiences may impact career development. Additionally, although this theory includes the impact of gender role socialization in the family structure—for example, if little girls are taught that it is acceptable to play with the kitchen set and not acceptable to play with the doctor's tool kit—it does not explicitly address the impact of race and gender (and other constructs) outside of the immediate environment. On the other hand, Henderson, Hesketch, and Tuffin's (1988) research using Gottfredson's theory found different results. They sought to analyze the circumscription stages in Gottfredson's model and the impact of gender typecasting in

relation to social background. The researchers used quantitative methods, gathering data from 396 school-aged children. They found that the person's individual ability superseded social background and experience.

Traditional career development theorists are critiqued (e.g. Cook et al., 2002; Niles & Harris-Bowlsbey, 2009) because their research largely focused on the career development of White male populations. Women, persons of color, and other diverse groups have only recently been recognized in research and literature, often with White women receiving the privilege of study in the writings. However, it is commonly noted that career development is impacted by a variety of factors such as gender, race, socioeconomic status, sexual orientation, environmental factors, and disability, for example.

Additionally, Gottfredson's (1981) critique of Super and Holland calls into question their focus on early interests and values with children and their parents. Her argument is based on their focus on these areas at the exclusion of sociocultural factors like gender, socioeconomic status, and family background. Gottfredson (2002) noted an additional critique of traditional career theory is the tendency to generalize differences based on group affiliation versus individual consideration, while Niles and Harris-Bowlsbey (2009) stated the importance of linking theory to practical techniques for career counseling. The underlying philosophical perspectives seemed to have created a belief that individuals can be grouped according to likeness at the expense of recognizing variation within groups. However, it is time for space to be made to recognize individual (within group) differences and multiple perspectives. Although the

traditional theories do not include factors directly related to Black women, they are still valuable for their contributions to our general understanding of career development.

Traditional career theories are often challenged primarily because the research was based on a fairly homogeneous group—White male population. Attempting to use these theories highlights a mismatch for diverse populations, primarily in terms of race/ethnicity and gender particularly for African American women. An overarching critique of the dominant research and literature can be summarized as subscribing to the following tenets:

> (a) that work is the most important aspect of people's lives; (b) that career decisions can and should be based on a rational matching of the individual's traits and attributes to the characteristics of occupations; (c) that career development should progress along a rational path showing continued upward movement toward greater responsibility, job complexity, and, it goes without saying, rank and financial rewards; and (d) that talent and hard work will be rewarded. It is a model based on the values of individualism and autonomy. (Betz, 2002, p. 335)

Betz' critique of the dominant discourse suggests that the discourse should be expanded to recognize the perspectives and experiences of those individuals from collectivistic orientations whose life careers do not mirror the models advanced by traditional theorists. In contrast to the traditional career theories, the ecological model is presented as a framework for understanding and framing career development for diverse populations.

Ecological Model

Expanding the traditional career development theories, Cook, Heppner, and O'Brien's (2002) proposed ecological model is grounded in the body of literature dedicated to career counseling perspectives, (e.g. Bingham, Ward, & Butler, 2006; Constantine & Greer, 2003; Peterson, 1997) and centers the experiences of women of color and White women and their interactions with the environment. Cook et al. assert, "A person's behavior is, therefore, a representation of the complex interaction among the myriad factors that constitute her or his life, referred to as the *ecosystem*" (p. 296). Two elements are highlighted within the ecosystem: (a) the individually-focused level, identified as the *microsystem* and (b) the global cultural environment level, identified as the macrosystem. For this research study, an African American female engineer's microsystem includes personal and psychological factors such as education, motivation, personality and values. Macrosystem components include opportunities and threats within the wider society over which the individual has little control, such as racial/ethnic discrimination and informal glass ceiling structures. Cook, Heppner, and O'Brien note that a key factor in their ecological model is highlighting the importance of the client's interaction with the environment, with an emphasis on racial/ethnic and gendered experiences.

A series of case study examples (Davidson & Huenefeld, 2002; Flores, Byars, & Torres, 2002; Hook & Ashton, 2002; McDonald, 2002; Perrone, 2002; Spanierman, 2002) were analyzed using the ecological model as a framework for examining women's career development. The studies were primarily based on factors influencing career

choice based on racial/ethnic perspectives; for example, career choice for a White high school student (Hook & Ashton, 2002) and a Mexican American teenager (Flores, Byars, & Torres, 2002); career choice based on sexual orientation for a Chinese American (Davidson & Huenefeld, 2002), and career options for a young mother participating in a welfare-to-work program (McDonald, 2002). However, two case studies were applicable to African American female engineers: one study focused on the experiences of an African American female student (Spanierman, 2002) and the other examined the experiences of a female engineer (Perrone, 2002).

Spanierman (2002) used a case study approach to analyze the experience of an African American graduate student from an ecological perspective. She selected the model for her case study because of its usefulness in "critically considering the norms, values, and assumptions of the dominant culture" (p. 332). Applying the model, Spanierman identified the macrosystem factors, consisting of institutional structures, as negative stereotypes, institutionalized racism, and limited role models. The microsystem factors included low self-efficacy, loneliness, and diminished emotional health. Because this model is grounded in counseling, the author concluded by addressing the interaction between the structural (macrosystem) and the personal (microsystem) and how counselors might address those challenges.

Similarly, Perrone (2002) used the ecological model for her case study example, which analyzed the experience of a White female engineer in a male dominated workplace environment. The female engineer did not feel respected in her position and was overlooked for a promotion. Perrone identified challenging career stereotypes and

norms based on stereotypical gender roles as key macrosystem elements influencing her career. Additionally, at the macrosystem level, there was a lack of mentorship and respect from colleagues. At the microsystem or individual level, support from family to pursue a nontraditional career conflicted with a lack of peer support, which influenced her personal perception. Like Spanierman (2002), Perrone provided implications for counseling and suggested client interventions. These case study examples primarily provide a practical understanding of the ecological model for career development; however, empirical research is needed using the framework in a variety of professions.

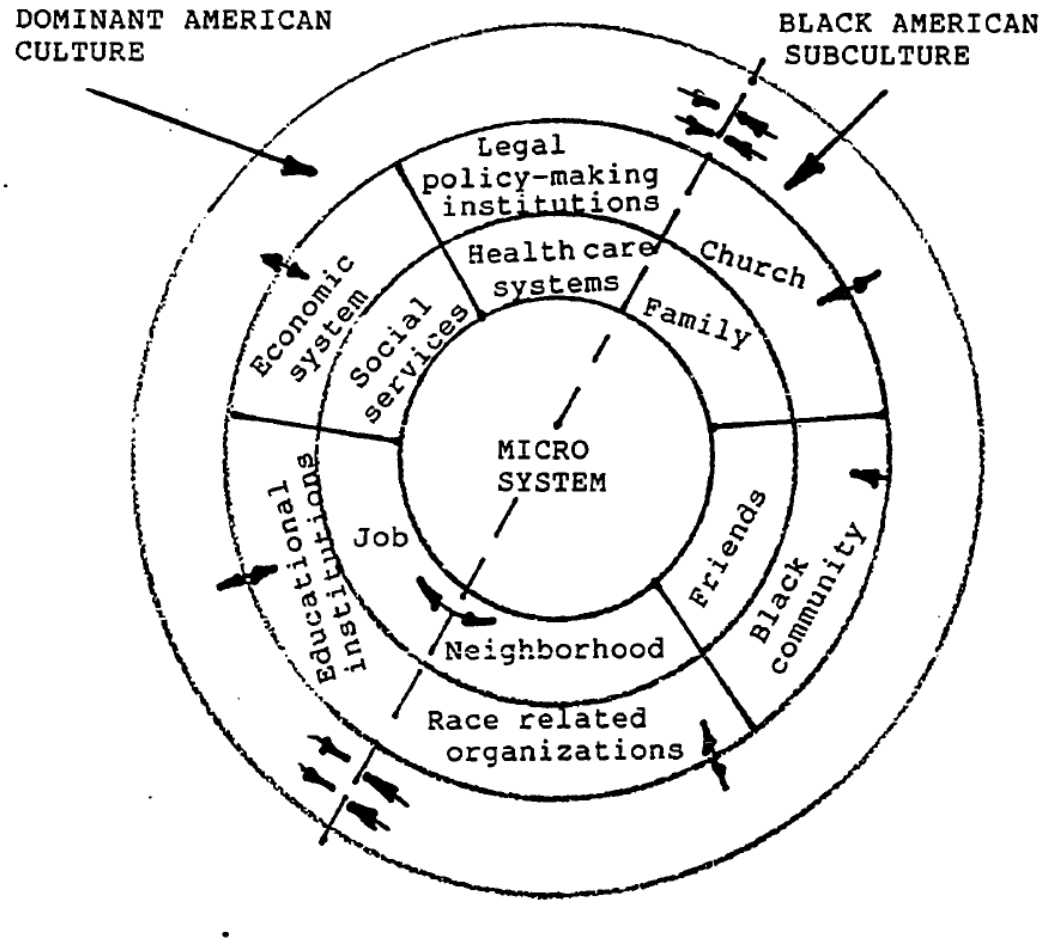
Betz (2002) provided a review of the ecological framework as a career development model for White women and women of color. She cautioned using the ecological framework because it is "an ideographic model—each person's "ecosystem" differs both qualitatively and quantitatively from the ecosystems of all other individuals" (p. 338). As previously stated, the ecosystem refers to the person's interaction with the environment. Likewise, the influence of the macro and micro level factors differs among the individuals. Additionally, she suggested that Cook et al. (2002) provide parameters and specifics regarding practical use of their ecological framework. Notwithstanding critique, the ecological framework provides the foundation for considering the interaction and impact of gender and race/ethnicity with the environment and as vital components of career development.

Complementary to the research using Cook et al. (2005) ecological model and focused on the experiences of women of color, Bell's (1987) research examined the bicultural life structures and stress factors for professional Black women utilizing

Brofenbrenner's (1977) model of environmental systems. In his model, an individual navigates through four systems—macrosystem, exosystem, mesosytem, and the microsystem—as part of the interaction with the environment. Bell (1987) utilized quantitative (i.e. questionnaires) and qualitative (i.e. focus groups and interviews) methods to explore the role of biculturalism and stress in the lives of 71 professional Black women. She found that the Black women in her study functioned under high levels of stress and managed complex life structures according to their inclination for family, community, or career preferences. Adopting Bronfenbrenner's model (refer to chapter I for model description), in her study, Bell proposed a theoretical model representing the components of stress and biculturalism (see Figure 2).

The macrosystem, as noted by the larger, all encompassing circle, is identified as the dominant American culture. The circle is split into two halves, with the right side representing the Black American subculture. Moving from the larger circle inward, the exosystem is identified by education and economic systems combined with the Black subculture, including the church, and community organizations. Continuing to move toward the inner circle, in the exosystem, Black women have minimal control in the subsystem components, yet are directly impacted by its output. As an example, Bell noted, "the Equal Employment Opportunity Commission and early affirmative action policy groups created occupational and educational opportunities for black women who for most instances, were not involved in the decision making process" (pp. 65-66). The circle immediately surrounding the mircrosystem is the mesosystem and it represents the opposite role regarding Black women's involvement.

Figure 2
Bell's Bicultural Life Culture Model (Bell, 1987)



In the mesosytem, Black women have a role in the subsystem components, for example the interaction of family, friends, and occupation. Lastly, the innermost circle represents the Black woman's microsystem and includes affiliations and actions for the individual. Bell's theoretical model posits how Black women are detached from the interconnectedness of the environmental factors that contribute to their life structure.

That is particularly true for Black women professionals who navigate environments and lived in both White and Black life worlds.

Black Women Professionals

According to the Bureau of Labor Statistics (2006), Black women are projected to increase participation in the labor force by 16.5% between 2006 and 2016. However, an increase in presence does not minimize the barriers for success. The Fact Finding Report of the Federal Glass Ceiling Commission (1995) noted disparities in pay scale, significant underrepresentation in senior level management positions, and a disproportionate number of Black women connected to jobs with no career path, to name a few of the challenges faced in the workplace. Extant literature presents segmented perspectives regarding the career experiences of Black women and can be grouped into the following categories, for example: barriers to career development (e.g. Burlew & Johnson, 1992; Evans & Herr, 1991), role of mentoring (e.g. Blake-Beard, 1999; Bova, 2000; Crawford & Smith, 2005), external factors (e.g. Bradford, Buck, & Meyers, 2001; Whiston, 1996), and comparative studies based on women representing different racial/ethnic backgrounds (e.g. Cocchiara, Bell, & Berry, 2006; Lopez & Ann-Yi, 2006). Conversely, there were common themes revealed regarding Black women's career development.

One theme discovered in the research addressing Black women's career development is the role of biculturalism. Bell (1987) defined biculturalism as, "the sociocultural repertoire of black women, as they move back and forth between the black community and dominant culture" (p. 21). Using biculturalism as a framework, Alfred

(2001) examined the experiences of five African American female faculty members, with tenure, in predominantly White institutions and particularly the factors that attributed to their success. Her research found that success for these women was accomplished by the participants creating a personal definition of self by discarding stereotypical images, creating a safe environment for affirmation, knowing the implied and explicit rules of the academic organization, maintaining a presence in their specific area or institution, and preserving systems that refueled and energized them as they navigated their careers in White dominated institutions.

Similarly, Bell's (1990) research paralleled the framework of bicultural identity as a lens to examine Black women's career development. However, Bell found that Black career women used compartmentalization to maneuver their bicultural identity which allowed them to maintain their separate identities: work identity at work and their home identity at home. The work identity resembled the findings by Alfred in that Black professional women understood and mastered the culture and expectations in the workplace. However, unlike Alfred's findings that revealed, after work, Black women were able to mask the identity required by the work environment and unveil their cultural identity while assuming roles as wife, mother, and community organizer. Bell found that some of the women in her sample struggled with the balancing act. She noted, "Their stories revealed that they were constantly proving their worth in order to compensate for their race and gender. The women got trapped in the never-ending struggle of having to be 'superwomen,' always competent and ready to perform" (p. 323). Likewise, Turner (1984) used the term "chameleon syndrome" when referring to

the bicultural identity; the process that Black women adopt to navigate work environments while dealing with racism and sexism. Her recommendations to address the 'chameleon syndrome' included employing communication techniques to maintain healthy work environments, determining alliances with different groups of workers, and developing skills to manage stress and discrimination in the work environment. Biculturalism was a key theme in the research regarding Black women's career development; however, other themes highlighted the impact of inequalities, images, and emotional challenges.

Johnson-Bailey and Tisdell (1998) used Farmer and associates (1997) social cognitive theoretical underpinnings as a framework for examining their personal career development narratives. Johnson-Bailey, an African American researcher collaborated with Tisdell, a White researcher, and found three areas that presented possible challenges for women of color: structured inequalities, stereotypical images for women of color, and psychological barriers. Structured inequalities referred to the notion that women are different and their experiences should not be categorized together. Like Alfred (2001), they propose that women of color and other minority groups have to be mindful of stereotypical images and consciously work to challenge the negative stereotypes about women and women of color in work organizations. Strategies to address psychological barriers for diverse women included rising above and working against socialized role expectations and cultural group affiliated norms. These themes—biculturalism, structured inequalities, psychological barriers, and stereotypical images—

provide a backdrop for examining the career development of African American female engineers.

Black Women in Engineering

A dominant discussion in the STEM field is centered on increasing the number of students, at the elementary, secondary, and collegiate education levels, to consider science, engineering, and other technical fields. Moreover, the majority of the empirical research, whether qualitatively or quantitatively designed, is focused on factors influencing career choice. This discussion is core for all students, understandably heightened for students of color, and certainly for Black female youth. Consequently, researchers attempt to answer the core question surrounding how students select STEM fields, what contributes to their decision, and factors that can be addressed to positively influence students considering STEM fields. Although, the research in this section is focused on career choice, there were different variables for consideration. The quantitative research covered the role of self-efficacy (Lopez & Ann-Yi, 2006; Johnson, Stone, and Phillips, 2008), barriers (Lopez & Ann-Yi, 2006), parental influence (Burlew, 1982), and cultural identity (McCowan & Alston, 1998). The qualitative research examined the role of the institution (Perna et al., 2009) and factors considered by African American males (Moore, 2006).

Lopez and Ann-Yi (2006) surveyed 359 female college students, at a Southwestern urban university, which consisted of a diverse racial/ethnic representation and varied academic classification. The purpose was to understand differences in the impact of self-efficacy and barriers (experienced or perceived) on career choice in

relationship to race/ethnicity. They hypothesized that Hispanic and African American women would report a lower self-efficacy and more barriers, regarding career indecision, when compared to White women. Their findings were contrary to their hypothesis in that they "found no significant between-racial/ethnic-group differences with respect to currently experienced educational barriers, barrier-related coping beliefs, or career decision-making self-efficacy scores" (p. 41). Although, African American women were more likely to have higher perceptions of barriers compared to the other groups, essentially the authors found there was no distinction based on race/ethnicity for the group's approach to career choice. According to this research, the perception of barriers for African American female college students could influence their decision to pursue a career in the STEM field and present an initial challenge possibly before entering the collegiate. Therefore, the perception of barriers should be addressed when dealing with college students and developing strategies to recruit African American to the engineering field.

Similar to Lopez and Ann-Yi's (2006) research on career choice, Johnson, Stone, and Phillips (2008) conducted a study to examine the relationship between race, gender, and self-efficacy for African American and female student's in the information technology (IT) pipeline. The researchers used quantitative methods by surveying 256 undergraduate students identified as Black or White, male or female. They hypothesized that women and African Americans would have a lower IT self-efficacy than their White male counterparts. However, the findings revealed the opposite. Black students had higher IT self-efficacy than White students. Though, women reported lower IT self-

efficacy levels. Since Black students reported a higher IT self-efficacy, the authors noted that there must be a stronger determining factor (besides self-efficacy) for Black students career choice and specifically for selecting IT as a career. They concluded that self-efficacy was not the most important factor and offered "a number of factors other than self-efficacy—including perceived discrimination, lack of similar role models, and differences in cultural values—may preclude African Americans from pursuing careers in IT" (p. 1015). Based on these findings, the engineering community gains insight into possible challenges that could negatively impact the engineering pipeline in academia and in the professional workplace. Increasing role models for African American women and creating a supportive climate will assist this group in pursuing a career in technology. In examining the research including Black women in STEM, a dominant theme was career choice.

Another body of work found relevant to research is that of Burlew (1982). While focused on career choice, Burlew's research differs from the aforementioned studies because her study centered on Black females and added the nontraditional career component. Burlew surveyed 147 Black female undergraduate students to understand the relationship of family role models, environment, and expectations on career choice and to compare data regarding those who select nontraditional career paths versus traditional paths. She hypothesized that Black women pursuing nontraditional careers had a higher self-concept than those pursuing traditional careers. The literature (e.g., Burlew, 1982; Burlew & Johnson, 1992) referencing nontraditional and traditional terms typically identify nontraditional careers as those fields occupied predominantly by men,

which includes the STEM disciplines. On the other hand, traditional careers are predominantly occupied by women, for example nursing, education, and social work. In the study, Burlew (1982) found that the role of the mother and her education and career background had a positive influence in women seeking nontraditional career fields. Additionally, she found that Black females were more likely to select nontraditional careers if they had previous work history. Although the research is dated from the 1980's, the issues presented and found have relevance for understanding today's women's career choice and development. For example, Burlew noted that women, specifically African American women, earned less than men, pursued low wage jobs, and were needed in larger numbers in the STEM fields. An additional parallel with her research included the notion that studies on African American women and factors addressing their career development were scant.

Like Burlew (1982), McCowan and Alston (1998) researched African American women and their career choice. However, they also added the role of identity to the list of factors influencing career decision. McCowan and Alston sought to "examine the relationship among racial identity, African self-consciousness, and career decidedness in first-year and senior women in both historically Black and predominantly White college environments" (p. 28). The authors surveyed 212 African American students at two comparable institutions: one historically Black college (HBCU) and one predominantly White college (PWCU). The researchers hypothesized that the senior level students at both institutions would have a higher level of insight into their racial identity and career choice. Their findings revealed that the racial identity variable had a stronger

association for the senior women at the HBCU than at the PWCU. However, in terms of career choice, they found that the senior women at the PWCU were more confident in their career choice than the women at the HBCU. The implications provided were targeted for college career counselors to help them advise female students of color in their career choice and to consider how their racial/ethnic and cultural identity development may be a factor (whether minimal or not) in their career decision and in their overall identity development. This research sheds light on the importance of the college environment as an external factor and racial identity as an internal factor in the career decision making process for young African American female engineering students. The external setting and the internal disposition can serve as challenges as well as systems of support for African American female engineers.

McCowan and Alston (1998) emphasized the importance of the environment on career choice for African American women. Similarly, Perna et al. (2009) focused on the environmental factors at a predominantly African American female college with a high success rate for graduating Black female students in the STEM fields. Perna et al. completed a qualitative case study to examine how one HBCU, Spellman College, contributed to and supported African American female students pursuing careers in the STEM disciplines. The authors interviewed 19 students (focus groups), three faculty members, and five administrators for data collection. Perna et al. found four themes, in their research, related to Spellman's support of Black women pursuing STEM fields: (a) the schools rich legacy positively impacts Black women in STEM, (b) the institution supports the student's solid foundation and future goals, as related to STEM areas, (c)

there is a general understanding of the barriers and challenges for Black women pursuing STEM fields, and (d) the institution has systems in place to address the challenges and barriers that Black women face in STEM fields. The study revealed that the combination of these elements provides the support and success structure needed to retain and graduate Black female students in STEM.

While Perna et al.'s (2009) study focused on women, Moore (2006) examined factors which contribute to African American males pursuing and remaining in STEM disciplines during college. Moore completed a qualitative study by interviewing 42 African American male, junior and senior, engineering students. The following factors were considered prominent in determining the academic and professional path:

> (a) strong interests in science, technology, engineering, and mathematics; (b) strong familial influence and encouragement; (c) strong aptitudes in science and mathematics; (d) meaningful academic experiences and relationships with school personnel; and (e) meaningful enrichment programs, opportunities, and academic experiences. (p. 250)

Based on the findings, Moore provided suggestions for secondary education personnel and parents to identify and support students inclined to consider STEM areas. Although the population is not an exact match (according to gender and student variability), the information gained from the research findings adds value to understanding the general dialogue concerning STEM and career factors among African Americans.

The empirical research in this area, although scattered in terms of focus, share some common elements. All of the research was focused on career choice at the

collegiate level. Research focusing on the factors influencing career choice for students is valuable in understanding career development for Black females holistically. Additionally, this body of research provides contextual information regarding the influence of background and early academic career factors for the study of African American women in engineering. An additional commonality within this body of research is that there appears to be a minimal relationship between race/ethnicity and career choice. This is possibly a result of the male domination in engineering which appears to be a stronger characterization in the STEM fields. Furthermore, the body of research in this category posits that environmental factors including parental roles, institution, and supporting staff (personally and professionally) are valid constructs for Black women considering STEM fields.

The majority of research pertaining to women and racial/ethnic minorities in STEM is concentrated on increasing the pipeline, career choice, recruitment/barriers, and retention of underrepresented groups in the K-12 and collegiate domain (e.g. Burlew, 1982; Johnson, Stone, & Phillips, 2008; Lopez & Ann-Yi, 2006; Moore, 2006; and Perna et al., 2009). Moreover, often in the research and literature, the experiences of racial/ethnic minority engineers are grouped into the same categorical experiences as women and this discounts the role that race plays in career development. There is little, if any, literature specifically focused on the career development or experiences of African American female engineers, which could provide the missing link in the discussion centered on creating positive change for diversity in STEM.

Summary

The literature in this chapter presented traditional career development theories, research supporting the ecological model, writings on the career development of African American women and the African American women in engineering. The traditional theories provided the backdrop for understanding career development historically and the factors that may impact the career experiences for the African American female participants. However, the traditional career theorists' research samples were limited to White males and, therefore, could not provide a comprehensive approach for understanding career development for women and people of color. Therefore, the ecological model was presented as an approach for addressing the intricacies associated with race/ethnicity and gender in career experiences of African American women.

The themes highlighted for Black professional women provided guidance for this study by noting the challenges and barriers that are often experienced by Black women in the workplace. Lastly, the body of work presented in the last section offers empirical and conceptual research and literature addressing the career development of African American female engineers. It is clear that the scholars presented do not provide a wealth of information on the specific topic at hand. Therefore, complementary studies were included that would inform some component relative to the targeted group.

Given that the targeted group is missing from the research, yet deemed important to the discussion regarding women and minorities in STEM, I summarized the pertinent literature, which highlighted the need for this dissertation research. This research adds the voices of women of color, in STEM, and it will inform the engineering community,

STEM organizations, HRD community, women, and women of color. Research on the career development of African American female engineers and African American women, holistically, will inform organizations about factors to consider in recruiting, retaining, and developing this group to be successful in the workplace.

CHAPTER III

RESEARCH DESIGN, RESEARCHER CASE STORY, AND PARTICIPANTS CASE STORIES

The purpose of this study was to examine the career experiences of African American female engineers. Specifically, this study sought to understand the microsystem and macrosystem factors that influence the career development for African American female engineers. Therefore, interpretive inquiry was the underlying paradigm guiding the research utilizing a life history approach (Cole & Knowles, 2001). This chapter provides the research design and methodology, the researcher's positionality and case story, and case stories for each participant.

Methodology

Methodology is the framework guiding the research to gain knowledge. According to Gough (2000) "Methodology refers to a theory of producing knowledge through research and provides a rationale for the way a researcher proceeds" (p. 4). The research design and approach are grounded by the purpose of the study and according to Creswell, also by the "researcher's philosophical and theoretical stances" (2007, p. 2). This study focused on how African American female engineers made meaning of their world and their experiences holistically (Merriam, 1998, 2009). Therefore, the underlying paradigm guiding the research was basic interpretive inquiry. Merriam and Associates (2002) noted that basic interpretive inquiry is a qualitative study where the researcher seeks to understand the participant's experiences. Accordingly, "In

conducting a basic qualitative study, you seek to discover and understand a phenomenon, a process, the perspectives and worldviews of the people involved, or a combination of these" (p. 6). This approach allowed me to explore the participant's lifespan and interpretations of their lived experiences. Scholars such as Creswell (2007), Merriam and Associates (2002), and Patton (2002), note several different approaches to qualitative research such as phenomenology, ethnography, grounded theory, critical theory, and case studies, to name a few; however, the basic interpretative qualitative approach most appropriately aligned with the purpose of the study.

Complementing the basic interpretive research design, life history examinations (Cole & Knowles, 2001) were employed to obtain rich data from the participants, which included exploring early life experiences that influenced their career development. With this approach, participants were encouraged to reflect on early life and school experiences and how they contributed to their career development over the lifespan. The person's storying of her life, her narrative on her life experiences are utilized and contribute to the development process (Bertaux, 1981). As Cochran (1990) noted:

> If we represent life in story, then telling stories to ourselves and others is part of life as lived. Part of career, for instance, is telling stories of the career we have had so far, have now, and want in the future. To represent a career, then, would partially involve representing the stories people construct about themselves and their life projects. (p. 73)

Individual historical representations add a rich tapestry for understanding holistically the elements that influence a person's career development as a dynamic process (Bujold,

1990) versus a snapshot in one moment of time, whether it is career choice, entry, redirection, or retirement, for example. Cole and Knowles (2001) further explained:

> Clusters of individual lives make up communities, societies, and cultures. To understand some of the complexities, complications, and confusions within the life of just one member of a community is to gain insights into the collective. In saying this we are not invoking an essentialist claim that to understand (however partially) *one* is to understand *all*. Rather, we are suggesting that every in-depth exploration of an individual life-in-context brings us that much closer to understanding the complexities of lives in communities. (p. 11)

Therefore, what we gain from the authors is the importance of understanding the life experience of one participant as it is significant to understanding the experiences of others. For the participants, each of the African American female engineers shares an individual narrative, which also provides insight into the experiences of others. Exploring their lives in relation to the environment gives the researcher the opportunity to pull the experiences together for a broader understanding of the contextual story as shared by the participants.

Merriam (1998) noted, "Qualitative researchers are interested in meaning—how people make sense of their lives, what they experience, how they interpret these experiences, how they structure their social worlds" (p. 19). In the same way, this study examined how the participants made meaning of their experiences, particularly those influencing their career development, as a woman and person of color. Josselson (1995) purports:

> Meaning is generated by the linkages the participant makes between aspects of her or his life as lived and by the explicit linkages the researcher makes between this understanding and interpretation, which is meaning constructed at another level of analysis. (p. 32)

The meaning the participants made between their early life experiences, educational pursuits, and workplace occurrences were valuable in understanding their experience in their totality.

In a qualitative study, the researcher becomes the primary tool for gathering data with the participants and generating knowledge (Creswell, 2007; Erlandson et al., 1993; Lincoln & Guba, 1985; Merriam, 1998, 2009; Patton, 2002). As noted by Erlandson et al. (1993), "The human instrument allows data to be collected and analyzed in an interactive process" (p. 39). The interaction between me as the researcher and the African American female engineers, contributed to the knowledge gained and allowed their voices to be captured. My goal was to obtain data "that allows for discovery rather than seeks confirmation of hypotheses and that fosters more exhaustive quests for explanation rather than the illusions of finding a preexisting truth" (Josselson, 1995, p. 30). In listening and learning from the African American female engineers as they shared multiple experiences and varied truths, I presented the knowledge gained in order to expand the dominant discourse.

Participant Selection

This research study targeted Black female engineers, working in an engineering capacity, in an engineering specific organization. Therefore, Black female engineers

working in a marketing function within an engineering organization, for example, were excluded from the sample. Likewise, Black female engineers working in a sales function for a business management firm were also excluded from the study. Additionally, the participants needed to have at least 10 years of work experience as an engineer and at least one promotion, or equivalent, from an entry level position. The aforementioned tenure and promotion conditions provide a sample with experience navigating the engineering culture. Initial participants were identified by working with professional engineering networks, for example alumnae listserv contacts. Additional participants were found by contacting engineering workplace organizations directly. In addition to these resources, snowball sampling was utilized to reach the individuals who met the criterion for the study. In summary, nine Black female engineers were purposively selected (Merriam, 2009; Patton, 2002) and agreed to participate in the study. The women represent varied undergraduate and graduate engineering disciplines, varied engineering industries, and have at least 10 years of engineering experience.

Due to the varied career paths, it is significant to note that although this research study included African American female engineers who received at least one promotion, or equivalent, from an entry level position, they were not expected to be in a managerial position. Moreover, this study did not include African American female engineers whose current position was in senior management or above. The reason for this exclusion was to focus on African American female engineers serving in engineering functions rather than high level leadership positions. This is important because one of the goals of this study is to inform the engineering community (e.g. K-12, higher

education, and workplace organizations) about possible factors to consider in recruiting and retaining African American women in core engineering professional roles.

Data Collection

Data were obtained primarily using in-depth interviewing employing a general interview guide approach (Patton, 2002). The general interview guide approach provided some structure to ensure that specific content was addressed during each interview; however, there was freedom in the sequence of the conversation, which allowed for a more conversational design, resembling Cole and Knowles (2001) description of a guided conversation. Accordingly, "The questions were deliberately open-ended and based on the principle of 'less is more' in the belief that broad, open questions that help frame an issue or event or circumstance, and allow wide latitude in responses, yield rich insights" (p. 73). The interview guide (see Appendix A) was constructed using a life history approach (Cole & Knowles, 2001) and the Cook, Heppner, and O'Brien's (2005) ecological framework. These two items informed the topics that were addressed during the interview including family structure and background, secondary education, higher education, and workplace environment. Additionally, this style of interviewing supported the researcher and interviewer rapport development and relied on the interaction and environment created between the researcher and the interviewer to discover data.

The first interviews lasted between 90-150 minutes and delved into the participants' life history and career experiences. The interviews took place at a location designated as a natural environment (Creswell, 2007; Patton, 2002) by the participant for

example the participant's home, office, or a public library. Follow up interviews were conducted to address specific experiences and points of clarification, as needed. Individual interviews were digitally recorded with permission, and transcribed verbatim.

Data Analysis

Creswell (2007) describes the qualitative analysis process as a data analysis spiral, which denotes the nonlinear and dynamic form of the analysis process. This process begins with multiple readings of the text to gain a comprehensive understanding of the data. Subsequently, the data is examined in smaller units for individual participant understanding. As a result, the data was analyzed in three phases: first, a case story was created; second, a thematic analysis was conducted for each case; and third, cross cases analysis was completed for common themes.

Phase One – Case Story. Initially, each interview required several readings of the text to gain a deeper understanding of the interviewee (Cole & Knowles, 2001). This process assisted in creating a case story for each participant, which was sent to the participant for member checking. The case story provides an overview of the participant and the factors which contributed to her academic and professional experiences as an African American female. The goal was to paint a portrait of the developmental experiences leading to and including the experiences in the engineering workplace. The case story for each participant is in the last section of this chapter.

Phase Two – Thematic Analysis. In the second phase of data analysis, the transcribed interviews were examined as individual units of data. Following Creswell's (2007) approach to data management, each complete transcript was organized into units

of data in Microsoft Word and printed on index cards. The cards were used to develop initial categories and each individual life story was categorized based on chronological events (e.g. elementary education, college experiences, and workplace setting). Once the interviews were aligned chronologically, a thematic analysis was conducted for each narrative (Riessman, 2008). Thematic analysis focuses on the content of the narrative (Riessman, 2008) in order to identify commonalities and differences amongst themes in the data. This was an iterative process as noted by Creswell, "This process consists of moving from the reading and memoing loop into the spiral to the describing, classifying, and interpreting loop" (p. 151). The themes were identified according to significant incidences in the participant's story (e.g. initial introduction to engineering, challenges, support systems, and sacrifices).

Phase Three – Cross Case Analysis. After the themes were identified for each narrative, then a cross case analysis was completed to capture similarities in the themes. The common themes across each of the cases were examined to identify common factors and differences in the findings. Lastly, once the common themes were organized the findings were identified as either a microsystem component or a macrosystem component. The corresponding findings are presented in each manuscript.

Data Trustworthiness

Qualitative researchers address data trustworthiness in order for the reader to assess if the findings are credible (Erlandson et al., 1993). Creswell (2007) further noted the importance of the qualitative researcher, as the primary tool for gathering data, in providing and following mechanisms which strengthen the dependability of the research.

Therefore, the strategies used to demonstrate trustworthiness in the data included member checking, peer debriefing, thick descriptions, and the researchers' positionality.

Member Checking. Member checking provides the participant with the opportunity to review the data before and during analysis for an accurate understanding of the information gathered (Creswell, 2007; Patton, 2002). Member checks were utilized during the first phase of the data analysis process. The participants were emailed their transcript from the interview to review and edit as needed. Only one participant elected to make changes to the transcript and the edits were primarily on correcting spellings for company names referenced during the interview. Additionally, the participants received the case story for review and again only grammatical changes were made.

Peer Debriefing. Peer debriefing was another strategy employed to ensure data trustworthiness (Erlandson et al., 1993; Patton, 2002). According to Erlandson et al. peer debriefing sessions can be informal discussions with colleagues and peers. As such, I met with professors and peers to discuss the findings and data analysis. These debriefings included conversations regarding the process used, noted findings, and expected findings, which were not found. While reviewing and analyzing the data, this strategy challenged me as the researcher to remain engaged with the details and open to all discoveries.

Thick Descriptions. An additional strategy, commonly utilized in qualitative research is the use of thick descriptions in presenting the data. As Patton (2002) noted, these detailed descriptions add to the data trustworthiness by providing the reader with

contextual information and a richer understanding of the findings. The narratives included in the findings provide thick descriptions, which assist the reader with understanding the totality of the experience.

Positionality. Lastly, I provided my case story and positionality in regards to the research study. It is important for me to reflect on my background, my perspective, my voice, and how these factors influence the research study. Therefore, my case story is presented in the next section to provide insight into my personal experience as an African American female who began my career as an engineer.

The Researcher's Positionality and Case Story

For all intents and purposes, I was not supposed to graduate from a top-ranked national university with an engineering degree; I was not supposed to work as a development engineer for a leading technology global company; and I was not supposed to leave engineering for education with the hope of making an impact on the engineering field. According to societal norms and expectations, I was best slotted for far less challenging paths because I faced some substantial challenges. My mother raised me and my two siblings as a single parent. Although she had some college credit before my twin sisters were born, she did not have a college degree, which limited her potential in her career in business and thus her earning power. However, whatever education she did not have formally, she certainly received through informal education and incidental learning as a single African American mother with three children. Therefore, she knew from her own life experiences the powerful need for her children to obtain a high quality education and, thus, she was always pushing us to do well in school.

A quality education meant that she chose for me to attend Montessori schooling during elementary and middle school. The Montessori format allowed me to work, and in many cases, excel in different areas of learning. It was during this time that I realized my love for math and my ability to grasp analytical concepts quickly. In middle school, my love for math increased and science began to peak my interest. I loved the program and core classes in advanced math and science, and I quickly realized how few students who looked like me were in the program. In other words, as I think back, I can remember no other African American girl in my advanced math and science courses. Little did I know that this experience would mirror all of my subsequent educational and professional experiences on this journey.

In high school, I had the opportunity to attend an engineering camp at Texas A&M University. It was during this camp that I realized I wanted to be an engineer. As campers, we were charged with designing, building, testing, and redesigning a bean bag launcher. In essence, we were engineers representing what I thought to be real life engineers. We were presented with a problem and worked as a group to develop a solution, using all of our perspectives, which included many different approaches. I loved it!

After this experience, I began my college journey at a large, predominantly White research institution in the South. In most cases, I was the only Black female in my core engineering classes. Occasionally, there were other students of color, albeit not Black, and women, but White. I often felt like I did not belong due to the demographic make-up of the environment and not being able to connect with any group. Therefore, I

typically studied alone or with other Black students even though we were not in the same program. Just being around other Black students, particularly the National Society of Black Engineers (an engineering student organization), provided a feeling of support and encouragement. As a Black female, I don't recall ever being asked to study in groups or participate in class group assignments with the White students. For my senior design project, all of the White students came to the class with a predetermined group. However, since I took the course in the summer, most of my peers who would have worked with me were not in school. Consequently, by process of elimination, I was paired with two Latino male students, who were also not asked to join the other groups. In the end, however, we were one of few groups to receive an "A" in the course and developed a valuable friendship as a result of this experience.

When I began the undergraduate program, my goals were to graduate with an engineering degree and earn a full-time position as an engineer. Completing these two tasks was my self-defined measurement of "success," and I was successful. I remember graduating from the university and thinking that I would never return to the institution. I was not pleased with my engineering experience because, in many cases, I was the only African American female and felt the burden of having to represent those voices in classes. On the other hand, experiencing the double minority status in college prepared me for the professional workplace environment. Nevertheless, I knew that I represented one of few African American females and was pleased to be such an ambassador, to make changes, and to use this status to help others behind me. Upon graduating, I accepted employment with Hewlett Packard—in research and development—supporting

and providing electromechanical interfacing for logic analyzers, oscilloscopes, and other testing devices.

Approximately five months into the position, something began to change within me, and I was not completely fulfilled. I enjoyed the company, my design group, the amount of responsibility I had received, the development opportunities, and the engineering work. But I felt incomplete, like I was missing something, and I wanted more. After two years working as a development engineer, I became disenchanted and disconnected from my engineering career at that time due to an unfulfilled passion to be an active contributor to my African American community and culture. I felt that since I was able to accomplish "success," I could help other Blacks and women to accomplish the same goal. I had experienced the harsh reality that there were too few women and people of color in engineering at that time, just as today. From that point, I knew I wanted to make a positive impact on the diversity solution for women and people of color in engineering. I knew that I wanted to support efforts to increase and add value to attracting more women and people of color to the technical fields including math and science areas, particularly African American women like myself. I wanted to assist with helping underrepresented students to be a "success" in engineering, as I had done.

My industry experience in engineering served as the catalyst for me exploring options to serve the community while incorporating my education and background. At the time, I did not know that what I wanted was to give voice to the experience of Black female engineers, other women, and other Blacks. I just knew that I wanted to do more to make a positive impact in this space. I believed I could help others be passionate

about engineering, math, and science. I wanted to share my story to inspire and help others get on a simliar path. I wanted to share the stories of others who often get overlooked and are not presented when you see a poster of what an engineer looks like or what a typical engineering environment looks like. At that time, my guiding thought was that others Black women could be me; they could be "successful" in engineering and I wanted to help make that happen.

I left the engineering workplace because I did not consider the corporate path to be the best path to make the impact I wanted to make. Thereafter, I pursued a few different areas before finding my path. First, I tried teaching mathematics at the middle school level with the notion that if I could get young students excited about math then I could make a difference, introduce them to engineering, and get them to consider the field as an option for the future. What I did not realize was that you need to enjoy working with adolescents and that it helps tremendously to have teaching experience for that grade level (which I did not). I quickly realized that I wanted to work with older students and decided that I could make an impact at the collegiate level. Therefore, I accepted a position as a career advisor in the engineering career center at my alma mater. From this perspective, I felt I could improve retention and mentor students in the engineering program to help them be "successful." This was an exciting move; I was thrilled working with college students, advising them and preparing them to be successful in the engineering world. It was also during that time that I realized the importance of an advanced degree within academia. This value was vastly different than the corporate engineering model. In the engineering workplace, if you were able to do

the work then you could work on a project. There were engineers without college degrees with several patents at the company. Conversely, in academia, one must possess a particular degree to apply and be considered for job advancement. Understanding the academic path facilitated my return to education to obtain a Master of Education and shortly thereafter to begin the doctoral journey. Reflecting on my education and professional experiences, I now understand how all of the dots on my engineering career map have come together to this point and informed my research.

Participant Case Stories

The remaining section presents a case story for each of the participants. These case stories are representative of the narratives shared to me as the researcher. It is my hope that these stories provide contextual background information on the African American women engineers in the study. These case stories do not provide the entire story for each participant, as that is not possible. Rather, the stories present some of the key topics discussed during the interview and provides a snapshot of the experiences in the participant's lives, which initiated their journey to becoming an engineer and their persistence and retention in the field.

Christine

Christine grew up in a small Texas town, in a working class family raised by both of her parents. Her father has worked as a barber all of his life and continues to work in the same field. Her mother has held many careers including working as a cosmetologist, real estate sales and mortgage processor, and currently works part-time with her income tax business. Christine has a sister who is five years older than her and currently working in the nursing field. She also has a twin brother who completed an Associate's degree and currently works in the engineering design field.

Christine's father worked long hours while she was growing up. Therefore, her mother is the person who supported and encouraged she and her siblings to focus on education and established the expectation that she was going to attend college. Consequently, Christine was focused on academic achievement and she was also balanced and participated in extracurricular activities.

Early education included public and private Catholic schooling for Christine. She remembered experiencing situations in which she was made aware of her race as a young child and understood that she was part of the integration education movement in her city. However, early in her academic career she knew that she enjoyed teachers who challenged her thinking and used creativity and interaction in the classroom. By the time she reached middle school, Biology became her favorite subject because the practical labs continued the theme of teaching to her learning style, with kinesthetic elements in the classroom. In high school, she continued extracurricular involvement participating in band (she played the flute and bass drum), National Honor Society, Spanish Club, and

cheerleading; and she maintained a majority A average with an occasional B on her report card.

Christine was first introduced and learned about engineering from a family friend while she was in junior high school. Her father had a network of professionals that included an African American male engineer. She met this man at her dad's barber shop and he imparted in her that she could become a successful engineer. From that meeting forward, she knew that when she attended college, she would become an engineer. She also knew that she wanted to attend one of the nationally ranked public engineering schools, because this man, whom she considered a mentor, had attended the same college system.

Christine attended two different high schools as part of a unique integrated magnet school program focused on engineering and computer science. For the first half of the day, she attended the magnet school for engineering and computer science curriculum, which was housed in a predominantly Black high school. This school included at-level students with the majority of the population represented by African American students. However, the students in the engineering technology magnet program were diverse, representing all racial/ethnic groups. For the second half of the day Christine attended her home high school for the basic required curriculum.

In high school, she really began to notice her affinity for mathematics and science courses. However, her likeness to mathematics and science did not mean that these subjects were the easiest for her; that was not the case. However, she enjoyed the courses, the challenge, and connected with the material.

The transition to college was initially challenging for Christine. Even though she had attended an engineering magnet high school, she struggled in the beginning with the engineering coursework. Part of the challenge was learning to deal with the freedom and self discipline required once she was independent and responsible for her own learning in the college setting. The thought of going back home after the first two semesters was enough to fuel her desire to push harder and prove to herself that she could do the college coursework. College required more effort than she was accustomed to in high school; however, she realized she could do it after earning a 3.5 GPA her second semester of college. That is not to imply that the coursework was easy for her because it wasn't. However, she knew that she could pull her resources together, dig deep and learn how to navigate the college engineering environment.

As a result of attending the magnet high school that was focused on computer science and engineering, Christine initially selected to major in electrical engineering. However, after learning about the other engineering majors from her peers, she switched to mechanical engineering, which was a better fit for her interests. While at her college, Christine participated in the National Society of Black Engineers and a historically Black sorority, which provided support for her while in school. She credits her mother, boyfriend, and one professor in the engineering department, as additional supporters in her support system.

Christine elected to participate in the co-op program and worked with an aerospace company for three terms during her college career; one long semester and two summers. Fortunately, she was able to gain experience in different divisions of the same

company to learn about the business overall and explore different areas of the company. However, there were challenges in the engineering environment specifically with the culture in the organization. She received negative perceptions of being a (Black) woman in the engineering field and dealing with issues presented by being a double minority in a predominantly White male environment. For example, comments were made toward her that assumed she attended a HBCU simply because she was a Black female and the comments had an underlying negative tone. However, Christine connected with another Black female who served as a mentor and provided support early in her professional career. Despite some of the challenges, the overall environment was not all negative. Consequently, Christine completed all three co-op terms with the same company, rotating to different divisions within the company. After her last term with the company and returning to school to complete her program, Christine received and accepted an offer for full time employment with the company.

Christine worked for the aerospace company for a year and a half before deciding to quit and pursue work as a contractor in the same field. She learned from another mentor about the financial rewards working as a contractor and wanted to explore the

possibilities in that realm. She was successful as a contractor, secured work with different agencies and companies within the same field (engineering design) and even worked as a contractor for her initial engineering employer. However, after a few years, she received an offer from her initial employer to return to the organization as a direct employee and she accepted the position, which supported her personal and family goals at the time.

Christine considers her professional career successful because she is able to work on the projects that she wants to pursue. Her professional goal is focused on remaining technical, in engineering design, as long as the financial compensation is commensurate. Christine continues to work for the same company in an engineering design role. She enjoys and is thankful for her current engineering role, and the flexibility it affords her to focus on her family. Christine may consider returning to a contracting role in the future; however, she will remain in her current role as long as possible.

Courtney

Courtney described herself as naturally mechanically inclined from an early age. In fact, when she was eight years old and the washing machine broke, she remembered tinkering with the cords and fixing the machine. Her father also tinkered with electronics and introduced her to the ohm meter and volt meter as a young child. Although she didn't have a concept for what it meant to be an engineer or the field of engineering overall, she knew that she enjoyed understanding how things worked and getting her hands involved with things.

She was raised in a large urban working class city in the North. Her family migrated to the North to find better jobs and most of her family worked in manufacturing plants. Her mother attended college and earned a degree in elementary education. However, she discovered that she didn't like teaching and moved into the social work field. Courtney's father didn't finish high school, however he completed his GED. Although he made a few appearances in her life, Courtney's father was not a significant figure during her childhood. Courtney has one older brother, who elected to join the military after high school. Besides her mother, Courtney is the only person in her immediate and extended family to graduate from high school, college, and to earn a graduate degree.

Courtney's hometown is a predominantly African American populated city and was not integrated too well. She described her elementary school as demographically 95% African American and 5% other. However, her fondest memory, during that time, came from her Caucasian female science teacher. The teacher provided hands-on

learning activities, which created a spark in her mind that science was fascinating. That interest continued into middle school.

As a single mother, Courtney's mom wanted her children to obtain a solid education and as a result felt that their neighborhood school was not up to par. Therefore, she secured entrance for Courtney and her brother to attend a magnet middle and high school outside of their district. Consequently, they had a 30-40 minute bus ride to attend school in a suburban community, which focused and prepared Courtney for the college track. The new school environment changed from almost completely African American to a 60-40 split, still with the majority of the students identified as African American. In middle school, Courtney remembered getting her best grades in mathematics and science; and she enjoyed band and played the clarinet. However, in high school she elected not to participant in band and focused on coursework.

Courtney attended a college preparatory high school, which was recognized as one of two premier high schools in the large urban city. She had to take an entrance exam to be accepted into the school and also had to declare an area of specialization for the high school course curriculum. Courtney selected the electronic curriculum as her high school major. Due to the structure of the school, the students were grouped into cohorts based on their declared area of specialization. Therefore, Courtney was with the same core group of students for her entire high school career. According to Courtney, the electronics curriculum largely resembled an introductory electrical engineering format. Mathematics was her favorite subject in high school and she enjoyed the kinesthetic learning in the electronics courses. Although all of her teachers were

Caucasian males, she felt that all of the students were treated fairly and encouraged to succeed. The electronics program was made up of majority African Americans, however only two other African American females were in the program with Courtney. In fact, she did not remember any Caucasian females and virtually no Latino students in the program.

She pursued her undergraduate studies in electrical engineering at a small, private, HBCU in the South. At her institution, the engineering curriculum was a structured five year program. The demographic at the HBCU resembled her secondary education experience, with approximately 95% of the students identified as African American. Conversely, the professors largely represented Asian subgroups. Courtney mentioned that it was sometimes difficult to understand the professors due to their accent. Although she didn't have large classes, with a maximum of only 50 students in the core engineering classes, she didn't necessarily feel that the professors took an active interest in her well being or success in the program. However, she described her primary challenge as herself.

Initially, Courtney described the coursework as familiar and comfortable, due to her college preparatory high school and electronics curriculum block. However, she quickly realized once her college courses delved into new territory or material she had not previously seen that she was not prepared. She didn't feel that she learned how to study properly and found it challenging to balance her independence and freedom with the academic demands. Consequently, her grade point average began to sink and she struggled. But she was determined to graduate and more importantly she realized that

she needed to get a job after graduating. Therefore, she pulled it together and matured quickly. Her peers also had a determination to graduate and they supported one another during all night study sessions and kept one another focused on their goals. Additionally, Courtney worked on campus in informational technology. Her full time coworkers at the campus job, who had already completed their undergraduate studies, also provided encouragement and mentorship while she completed the engineering program. Another motivator was her off campus job at McDonalds, which consistently reminded her that she needed to graduate to avoid working there full time.

During her time in college, she completed one internship, working in aviation communications and she thoroughly enjoyed the experience. Specifically, she worked on developing and maintaining communications systems for airplane landings and this exposure planted the seed for her interest in electronic communication from a practical standpoint. After graduating she hoped to return to this company; however, they were not able to extend an offer for employment due to restructuring in the company. Therefore, she graduated without employment and eventually had to return home with her mother. After a few months working as an engineering contractor with different companies, Courtney secured a position with an architectural engineering firm in the electrical engineering division. The firm secured projects, which provided data centers and networking to other technological companies. Courtney was able to use the electronics communications experience from her internship to gain experience in top projects with the firm. However, after six years that particular data infrastructure

industry began to slow down, which meant her projects decreased and ultimately led to her returning to school.

With the change in industry as a catalyst, Courtney decided to return to school and obtain a Master of Business Administration (MBA) as a full time student. She wanted to learn about the business side of engineering management and supply chain. While in the MBA program she completed internships and eventually accepted employment with a large automotive company in the supply chain business unit. Courtney worked on the business side of the industry for five years before returning to her engineering roots. The reason she returned to engineering was prompted by her husband who accepted a position that relocated them to the South. Since she had to seek a different employer, she began to think about her long term goals and felt that returning to engineering would help her accomplish future entrepreneurial ventures in engineering. Therefore, she accepted an engineering design position, returning to her architectural firm experience with a company in central Texas. Regardless of the type of organization, Courtney has consistently dealt with challenges in the professional engineering environment.

In her professional experience, Courtney was routinely aware of her status representing the only person of color and/or female of color in the engineering workplace. Although there may have been others in the organization, she recalled typically being the only African American female or one of two women engineers in the organization. In those environments, she felt that she was not able to connect with the majority and relied on few individual relationships for support. The relationships were

typically developed with those also in the minority, such as the only other woman in the group or the only other person of color in her group within the firm. These small pockets of support helped her to deal with the political structures, conflicts in the workplace, and aggressive and hostile workplace environments.

At the end of the day, what keeps Courtney sustained in the engineering environment is that it allows her to focus and accomplish other personal goals. In her current role she is focused on electrical design and project engineering management. Most recently she earned her professional engineering (PE) license, which allows her to provide signature authorization and seal the engineering drawings at her firm. The PE designation also makes her marketable for other engineering organizations in a variety of industries. Additionally, she spends significant time engaged in activities outside of the workplace to develop and nurture young African Americans to pursue technical fields. Her focus at this time is to gain as much experience as she can to pursue her entrepreneurial goals in the near future.

Jasmine

Jasmine grew up in a small/mid size city in southern east Texas where she was exposed to the engineering environment, particularly the oil and gas industry and the refinery business from an early age. She is from a dual parent working class yet formally educated household. Both of her parents were in the home and contributed to her upbringing. Additionally, her father did not attend college but her mother completed her undergraduate degree in education. Despite not having a college education, her father worked significant hours in the local refinery to ensure that the family's needs were met. Her mother went on to earn a master's degree in Guidance and Counseling, worked her way through the secondary education system as a teacher, curriculum coordinator, counselor, and currently works as an assistant principal. Jasmine has a twin brother who followed in their father's path. Her brother attended college and then moved on to work in the oil and gas industry as an operator.

Growing up, Jasmine described her childhood neighborhood by stating, "it wasn't the worst town but it was next to the worst when you compare the city." Her community was predominantly African American and the elementary school in her area followed the same demographic. Consequently, her parents decided that she and her brother would not attend their home school for elementary but a school in a different neighborhood. However, due to the demographics of the city, that school was also made up largely of African Americans with a small percentage of Hispanic students. Her best subject in elementary initially was English because her mother was an English teacher and that is what she focused on with Jasmine. However, her father's strengths were in

mathematics and science and those subjects quickly became the topics of interest. Jasmine fondly remembered working on projects with her dad for the science fair and for mathematics skills development. Overall, Jasmine enjoyed her elementary schooling years.

In middle school, grades 6-8, Jasmine's family moved to a different part of the city, which she stated was a better part of town. At this school, Jasmine described how the school was modern, had better resources, and the teachers had expectations for all students to work hard and put in effort. The demographics changed in the new school, with the majority of the population classified as Caucasian, however African Americans, Hispanics, and very few Asian students were also represented. During middle school, Jasmine continued to excel academically and was placed in the gifted and talented program. Additionally, she played volleyball and participated in student council. It was also during this time in her academic career that she was formally introduced to engineering.

Jasmine participated in an engineering program sponsored by the Texas Alliance for Minorities in Engineering (TAME) beginning in seventh grade, which initiated her interest in pursuing engineering as a career. In addition to promoting mathematics and science topics, the organization introduced the students to practicing engineers, to learn more deeply about the field and consider a possible career in the field. Likewise, TAME took the students on college tours to visit engineering programs and obtain an idea on what the college environment was like and what to expect. Jasmine enjoyed the hands on engineering environment and the action and creation components involved in the

engineering profession. She maintained her connection with TAME throughout middle school and high school.

Her high school career began by attending a ninth grade center for one year and then continuing to the main campus for grades 10-12. There were only two ninth grade centers and one public high school in the city. Therefore, the demographics changed again and resembled a mix of both her elementary and middle school. However, she stated that the administrators were predominantly African American while the teachers were primarily Caucasian. She continued her academic track in honors classes, which included accelerated learning and smaller class sizes. There was also more competition in high school, which meant for Jasmine, that she would focus on academics and eliminate the extracurricular activities that she participated in during middle school. However, she started playing the clarinet and joined the band her sophomore year and continued until graduation. In high school, her favorite subject switched from mathematics to science because she enjoyed the kinesthetic learning activities conducted in her science classes. Nevertheless, as she thought about and prepared for college, she knew that engineering was her targeted major and goal.

Jasmine applied to colleges and universities in Texas, Atlanta, California, and Louisiana. After financial factors and rankings for engineering programs were assessed, she elected to attend a large research, predominantly White, public university in Texas. Coming into the university, Jasmine felt prepared for the demographic environment, where she was considered a double minority, due to her secondary education experience. She also felt prepared for the competitive nature due to her educational path in the gifted

and talented and honors programs. However, there was still a different and indescribable feeling, as she shared, while sitting in an introductory engineering class and hearing your professor state, “Look to the left and look to the right; these people won’t be here after this semester.” Thankfully, Jasmine came into the engineering program with a core group of friends who became her support system at the university and her best friend also majored in engineering. However, her core group changed because many of her friends left the large research, predominantly White, public university to attend a historically Black university for a more welcoming environment.

Jasmine described her university as unsupportive and especially challenging since there was not significant representation of students who looked like her. Although, she felt prepared for the demographic environment at the university level, the feeling was quite different and more challenging in the engineering environment on campus. Specifically, she felt that the professors were not helpful or supportive when she visited with them during office hours or after class for additional assistance. However, she created a support system by joining the National Society of Black Engineers (NSBE) and the Society of Women Engineers (SWE), connecting with the Equal Opportunity in Engineering (EOE) office, and developing relationships with staff members in the engineering support programs on campus. It was through those relationships with her network that she secured summer internships and full time employment.

Jasmine’s first internship was completed the summer after her senior year in high school. A large oil and gas company sponsored a scholarship award for students in her high school and as an award recipient they provided an internship for the summer before

her first year of college. After completing her first summer, she enjoyed the financial compensation and the learning experience and decided to continue working there for two additional summer internships. Later, she gained additional summer internship experience at a large city Light and Power Company in environmental engineering. She enjoyed learning about the different opportunities and career paths that she could pursue with a degree in chemical engineering and learning about different company cultures. However, in both environments she was the only African American engineer. Nevertheless, Jasmine consistently sought out mentors and was not limited to those formally educated or degreed or those who matched her racial/ethnic or gender identity. Although, Jasmine enjoyed her summer internships with both organizations, she selected to join a different company for her full time professional engineering career.

After graduating from college, Jasmine accepted an offer with an international oil and gas company headquartered in a Southeastern city in Texas. The company had a set rotational program for the first three years as an engineer, where you work in different locations across the US and sometimes nationally on projects that typically last 12-24 months. For her first assignment, they relocated her to a very small town in the North Midwestern part of the country. Her first two years were the most challenging years of her career with the company. She shared stories involving racism, sexism, and complete disrespect as a professional and an engineer. She stated,

> I've been here for 12 years going on 13, and I told them if I didn't quit in my first two years, ain't no way I'm quitting now because those were the hardest, those

were the worst. You know, my first year was by far something that I just couldn't even believe…there are people [who] still exist in the US, who act like this.

Oftentimes, she thought about and wanted to leave the company and the industry. She shared moments when she called home crying to her parents however they, particularly her father, encouraged her to persevere for a few years before she made the final decision. Ultimately, it was because of her family support and encouragement from her friends that kept her going in the hostile work environments, while rotating and relocating to small cities and working on the oil rigs.

Jasmine elected to remain with the same company. Since then she's been given more opportunities and explored a variety of functions using her chemical engineering degree. As a result, she has been able to work in a variety of different functional roles including line management, production, training and development, and environmental engineering. Consequently, she never gets bored with engineering or the company and looks forward to continuing to grow and learn as an engineering professional.

Josephine

Josephine first learned about engineering while she was a junior in high school. She was invited to participate in a summer engineering program at a Historically Black College and University (HBCU) near her hometown in Louisiana. Her primary motivation for attending the summer engineering camp was to get away from home for the summer. She was not seriously interested in engineering because at the time she initially thought engineers were the people who drove/conducted the trains and that was not very appealing to her. However, after attending the summer camp and learning the details of engineering, exploring the different types/fields of engineering study, and meeting and interacting with African American engineering professionals, she became interested in the field of study. And she was more than simply interested in engineering, as she stated:

> It was during that summer that I really learned…about engineering, and I felt as though, as I was taking these classes and working as part of teams in the lab assignments. You know, I felt that this is what I was born to do. I found my purpose, more or less, in terms of what I wanted to do. And so I made the decision then to major in electrical engineering…

Although her initial attraction to attend the engineering camp was fueled by her desire to get away from home for the summer, her family life was enjoyable.

Growing up in a small city in Louisiana, Josephine was the typical teenager in the sense that she did not like to do household chores. In fact, the reason that she wanted to get away for the summer was to escape doing chores, specifically washing dishes.

Prior to selecting engineering as her chosen profession, Josephine's only requirement for her profession was that it allowed her to purchase a dishwasher.

Josephine was raised by a single mother because her father was killed in an automobile accident by a drunk driver when she was two years old. She has an older sister, by one year, a younger brother by one year, and a younger sister by almost three years. At the time of his death, her father was in the military, which provided excellent benefits for her family and ensured that they had everything that was a critical need at the time. Her mother also had her extended family in the same city, which provided additional support for the family including aunts, uncles, and cousins to create positive memories during her childhood years. There was always an extended familial expectation which promoted education and Josephine emphasized how the family, "always encouraged us to do well in school, to get an education, to go to college. You know, we were going to college, it was not if we were going, but where we were going to college." As a result, most of her cousins are engineers and the majority in electrical engineering. Before she and her family members became engineers, they experienced segregation and then integration during their early childhood educational years.

For the majority of her elementary education, Josephine attended a segregated school in her small town. School integration occurred when she entered the fifth grade and even at that time, the students remained predominantly African American while the teachers included Caucasian representation. Regardless, Josephine enjoyed learning, school, and her teachers. She was often described as a good student and she felt that all

of her teachers encouraged her. However, the population changed significantly in middle school.

In middle school, the school demographic changed from students being predominantly African American to majority Caucasian. Although all of the schools were supposed to be integrated, she remembers that her school was the only school that appeared to be integrated according to the population distribution. Josephine's middle school included grades seventh through ninth; high school included tenth through twelfth grade. In middle school and high school, her favorite subjects were mathematics and science. Although, her school did not have a formal advanced placement curriculum (as the program exist today), she self elected to take every mathematics and science course possible, which was significantly more than the basic required courses for graduation. Therefore, she placed herself on an advanced curriculum track because her goal was not only to graduate from high school but to continue her studies in college.

In addition to enjoying the academic challenges inside the classroom, she also participated in extracurricular activities. In middle school, she ran track and was elected President of Student Council. This was certainly an accomplishment that she was proud of considering she attended an integrated school with a majority White population. By the time, senior year rolled around in high school, Josephine already knew that she was attending college and where she planned to attend.

Several of Josephine's extended family—aunts, uncles, and cousins—had attended a local HBCU and majored in engineering; Josephine kept the family tradition. She attended the HBCU and majored in electrical engineering immediately after

graduating from high school. Coincidentally, a few of her cousins graduated and attended college with her during the same year and two also pursued engineering. Therefore, she described her transition to college as relatively easy with family and friends from the summer engineering program that introduced her to engineering, and even professors from that same summer engineering program. In college, she described her professors as very supportive and her overall time as an undergraduate student as the best years of her academic career. Josephine described the engineering classes as not very challenging and she was able to tutor other students in the program. However, she also stressed that she was extremely focused on her academic goals and spent diligent time studying and prioritizing her academic responsibilities above all other activities in college. She did find time to join a Black Greek Letter Sorority; but, her commitment to academic excellence was not compromised. Not only did she have a personal goal for academic achievement, Josephine truly enjoyed learning, so much so that she decided to continue her academic career by entering a graduate program to obtain a master's degree in engineering.

Josephine earned a National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM) fellowship, which provided a summer internship after her junior year in college and the summer after graduation, covered tuition and fees, and provided a yearly stipend. Once she was selected as a GEM fellow, the companies selected the students they wanted for the summer internship, and she was selected by a major research laboratory, which designed weapons. This did not appeal to Josephine and after the first summer, just before her senior year of college, she requested

a company reassignment. Normally, this was a difficult process however due to the personal reasoning supporting her request, the GEM program coordinator sought to honor her request for a change.

After returning to college to complete her senior year, Josephine learned about another graduate funding program, the Cooperative Research Fellowship Program (CRFP), which was a Ph.D. program. Although, at that time, Josephine was not interested in earning a Ph.D. she was interested in earning more money and the CRFP program paid $1k monthly whereas the GEM program provided $5k yearly. Her plan was to participate in the CRFP program long enough to earn a master's degree and then drop out of the program and begin working in industry. So off she went to an elite private engineering research institution, on the west coast, to pursue a master's degree in electrical engineering.

The elite engineering research institution provided an extreme culture shock. Although she grew up in integrated schools for secondary education, her undergraduate experience was predominantly African American and overwhelmingly supportive. At her new institution, the environment was the exact opposite and described as "hostile" by Josephine. She shared experiences with professors and White students in her classes, where she felt extremely isolated primarily due to her racial identity. Appreciatively, students from other countries befriended her, as they were also isolated by the majority population, and they formed a support network. There was also one other African American, who happened to be female, in the graduate engineering program, who completed the support system during this time. A few years into the program, Josephine

learned about a professor who conducted research on the inferiority of Blacks in education and this infuriated her and fueled her to continue in the CRFP and earn a doctorate degree. She wanted to prove him wrong and she did. She transferred to a private elite research institution in the South which was more welcoming and supportive for her doctoral studies, relative to her previous environment, and completed a Ph.D. in electrical engineering.

After completing her doctoral degree, Josephine accepted employment in the research division of a large, global, technology company. Initially, the environment in the research division reminded her of the hostility she experienced while pursuing her master's degree. In describing the culture, she stated, "They challenge your thoughts, they challenge what you do, and in many instances for engineering because it's all male or overwhelmingly male at that time, they do it in a hostile way." During her time in research, she stated that there was no other African American female research engineer in the division. However, in that environment she was able to find a core group of people, with whom she connected on different levels professionally and personally, who became her friends and her support group. After 12 years in research, she was guided by a mentor to learn about a different component of the business and therefore switched to development. After a few weeks in development, Josephine decided not to return to research because she enjoyed the friendly culture in development and enjoyed seeing more women in the environment. Currently, she is excited that she gets to work on projects that are professionally and personally rewarding and that allow her to travel to developing countries focused on developing technologies for economic sustainability.

Lisa

Lisa grew up in a large urban city in Texas with both of her parents in the home and actively involved in her upbringing. As an only child, her parents were very focused on her development and exposure to educational activities. Her dad provided her first experiences and an introduction to engineering. When she was seven years old, her father purchased a science kit, which included test tubes and chemicals to mix for reactions and a frog to dissect. She enjoyed conducting experiments and what felt like creating science to her. Both of her parents were formally educated and stressed the importance of education in the family. Her mother began her academic career in education, focused on child psychology. She later earned a doctorate in psychology and continues to work in the field. Her father earned a business degree, joined the military, and then maintained a professional career. Lisa grew up as an only child and enjoyed her childhood experience.

She attended a private Christian based school for elementary, junior high school, and high school. From the early childhood years, in elementary school, she realized that she was stronger in the mathematics and science content areas. Her schools did not offer a specialized talented and gifted program because in essence the schools were modeled like talented and gifted programs. Initially the students in her elementary school were majority Caucasian but by the time she left the school, in sixth grade, it was an even split of African American students to Caucasian students. All of the core subject teachers were Caucasian; the only African American teacher was the physical education instructor. Overall, Lisa enjoyed her elementary education experience.

Lisa's parents felt that she had reached her maximum potential at the previous school and that there were limited resources and space for growth. Therefore, they moved her to a different private school to complete her secondary education. The new school offered her the opportunity to participate in athletics where she played basketball, volleyball, and ran track. In the classroom, Lisa didn't have any African American teachers nor did she remember seeing any African American teachers. However, her teachers were equally split between male and female for core subject areas. The students in the new school were majority Caucasian: she recalled that approximately 20% were African American and Hispanic. The high school was considered a college preparatory school consequently, she began to take advanced placement courses and focus on the courses that would prepare her for the next step on her academic journey, which was college.

Although she took advanced courses in high school, Lisa considered the Bible class as the course where she learned the most new information. She enjoyed the class discussions and different perspectives shared amongst her peers in the class. When discussing her mathematics and science courses, she felt that although she learned new information in those courses, she was already conditioned to think analytically and quantitatively, so the Bible class was a different way of learning. She enjoyed the other courses, particularly her mathematics course because the instructor was challenging, had high expectations, and demanded a lot from her students. The learning environment, in the mathematics class, appealed to Lisa and kept her engaged and interested in the course. It also prepared her for college level work.

Lisa knew that she was attending college and due to her father's influence at a young age, she also was focused on engineering early on in her academic career. In addition to her father introducing engineering, during the summers after her seventh and eighth grade years in middle school, Lisa attended engineering camps that targeted minority students and invited them to a local university for six weeks. During the camp, the students conducted experiments, built models in the lab, and tested their designs for competition. The camp also introduced her to practicing engineers representing the technology, power, and telecommunications industries. As a result, she entered college focused on the type of engineers that she had previously been exposed to.

Lisa attended a large, public, predominantly White research institution in Texas and majored in electrical engineering. The primary factor for selecting the university was due to her acceptance in the school and the full academic scholarship package awarded by the institution. She was also invited to participate in a program for high achieving incoming freshman students the summer before her first year of college. This residential program allowed her to take two courses and get acclimated to the campus before the massive and majority population arrived on campus for the fall semester. The program targeted students of color and created a sense of community and support from the very beginning of their college career. The camaraderie with her peers in the incoming class was extremely beneficial once the fall semester began and she experienced being one of few African Americans in her engineering courses. Thankfully, she felt comfortable approaching the majority White male population in her courses due to her experience in secondary education. However, that didn't mean that

she didn't feel excluded from activities by the majority population, primarily because she was female and secondarily because she was African American. In most cases, she was the only African American female in her courses due to the natural sequence of courses for students. Although these challenges were presented, Lisa was not going to quit and give up her goal of graduating and working as an engineer.

In the moments when she felt challenged and tested, Lisa relied on her support system, consisting of her parents, her peers in the National Society of Black Engineers, her sorority sisters who were also in the college of engineering, and her boyfriend, now husband, who was also pursuing an undergraduate degree in engineering at another institution. She also had supporters in professional engineering organizations where she had completed summer internships.

Lisa's first summer internship was with a high performing international telecommunications company in an urban city in the South. She worked the summer after her freshman year and was invited to return for the following two summers as well. Lisa worked and gained experience in engineering design, assembly and manufacturing, and product testing. She had a White male supervisor for the first summer and a Nigerian male supervisor for the last two summers. She described the professional workers as consisting mostly of White men and the factory workers as predominantly African American. She enjoyed her summer internship experience and she felt that she could have established a career at the company. However, after her last internship, she returned to school for her senior year and began to evaluate her marketability for full time employment.

During her senior year, Lisa felt that her grade point average, although not bad, was not as strong as she wanted it to be. She felt that her grade point average was not high enough for her to be highly competitive while recruiting in the market at that time. Therefore, she decided to attend graduate school, pursuing a master of science in industrial and safety engineering, at another large, public, predominantly White research institution in Texas. During her first semester in the graduate program, she connected with a large technology company who sponsored her graduate work for the second year of study and ultimately became her employer for 10 years after she graduated.

Lisa worked in manufacturing as an equipment engineer to support microchip processing. This environment directly related to the training and knowledge gained in her graduate program. She enjoyed the responsibility, leadership, and experience gained in the professional organization. However, she did not enjoy the "good old boy" system that reacted negatively to her once she was given leadership and management responsibilities.

She also felt that her age at the time, being in her twenties, was problematic for the mature population who had been in the same environment for most of their professional career. She did receive support from her direct supervisor and considered him her mentor at the company; however, she recently decided to change organizations and experience a new environment.

Lisa joined her current company approximately 15 months ago to delve into engineering project management and gain exposure to engineering consulting. Her function remains centered on safety and risk assessment with equipment management. She also continues to be challenged by the informal social networks within the majority White male population, which sometimes make it difficult to interact and establish professional connections. However, she enjoys the challenge of starting a new career in a different industry, which keeps her motivated in the field. Ultimately she would like to retire early and work on an entrepreneurial venture created with her husband.

Monica

As a young child, Monica's mother always told her that she was going to be a lawyer, doctor, or an engineer. Initially, she could not understand why her mother wanted her to drive trains, which is what she thought an engineer's responsibilities included. Additionally, the way Monica received this charge from her mother was as if those three careers were her only options for her and her siblings. However, out of her siblings, Monica was the only person to follow the guidance provided her mother. Her younger sister decided to pursue a career in theater and film. Her younger brother attended college for two years but dropped out and is evaluating his career goals. Monica's mother attended an HBCU in the South, graduated with a degree in mathematics, and has worked in the oil and gas industry for her entire career. Her father attended the same institution, majoring in engineering technology, but only completed two years and began working in mechanical technology roles. Her parents were married just after college and had three children. Education was stressed from the very beginning. An "A" on a report card was the expectation and a "B" on the report card was unacceptable.

Initially, Monica attended a private elementary school and her family lived in a large urban city in the South with a diverse population. However, in second grade, the family moved from the urban city to a rural town and her elementary school consisted of a majority White population. Monica enjoyed elementary school and was placed in the gifted and talented program from the outset. She and her best friend were the only two African American students in the program at her level. She liked taking classes with the

same group of students from elementary until high school. The small town had one elementary, one junior high, and one high school. Therefore, she was tracked in the advanced and competitive program throughout her childhood educational journey.

Monica appreciated how the students in the advanced program were extremely competitive because they were also friends. Therefore, she felt the educational experience challenged her and brought out her best academically. It was also during this period, between middle school and high school, when she began to realize that she was more advanced than her peers from an academic perspective. If she took at level courses, for example her foreign language course, and was not challenged then she became disruptive in class. Her strongest subject in high school was mathematics and she received an award for her high achievement in mathematics. Additionally, in middle school, she began participating in basketball, volleyball, track, and band. In high school she maintained her participation in sports and band while adding the honors club, math club, and prose competitions. She also began to understand her strength and continued interest in mathematics and science courses, which helped her refine her selected major for college.

Monica decided to attend a large, public, predominantly White, research institution in the South. When she entered the university she planned to major in pre-med and eventually become a doctor. Of course, the only three professional career options that she had, according to her mother were lawyer, doctor, or engineer. She quickly canceled out the lawyer career path because she thought it would require too much reading. Therefore, she selected chemical engineer pre-med as her initial career

path and incoming major at the university. The summer before her freshman year, she was invited to attend a summer program for high achieving students of color. This program allowed her to take two college courses before the masses returned to campus for the fall semester. Also, this program allowed her to form a community and support network for the duration of her college career. This proved well for her once the fall semester approached and the campus felt completely different than it did during the summer.

During the summer program, she was able to connect with a significant group of incoming African American students representing all majors. She was especially pleased to see the noteworthy number of African American boys who were also considered to be academically focused. To Monica, it felt like an improved version of her talented and gifted days in middle school and high school and she loved the experience. However, when the normal student body returned to campus for the fall semester, the environment changed drastically. She quickly experienced being the only or one of two African American students in the class. Of course, she was used to this experience from her secondary education in the talented and gifted program. Initially the coursework was manageable, to not significantly challenging; however, things changed during her sophomore year in college.

Monica's second year of college presented different challenges for her because she joined a sorority and the information presented in classes became more difficult. She began to lose focus on her role as an engineering student and was not able to manage the challenges she faced in this new and uncomfortable role of not

understanding the material presented in class. However, she pushed herself through that time period and utilized her study group to keep her going. Monica relied on her peers in the National Society of Black Engineers (NSBE) for study groups; she never approached the majority population and she recalled that they never approached her about studying together. Moreover, NSBE was an invaluable resource for her as a student by the peer network it provided, conferences and conventions, and professional networking, which supplied her first internship.

Monica completed two internships in large oil and gas corporations in the South. In the first internship, she worked in a small rural area servicing oil wells and ensuring that they were operating properly. She was the only female (besides possibly an administrative assistant) and the only African American. She felt that position was probably not the best introductory assignment for a summer internship because of the demographic challenges, and she wasn't exposed to the corporate company culture. Monica enjoyed the experience at the plant and gained practical engineering knowledge. Her second internship was in a similar company but she was located in a large urban city. The practical knowledge was also similar to the first; however, she worked in an office setting and enjoyed learning about the corporate culture. She completed an additional internship the summer after her fourth year.

Her last summer in college, Monica had to attend summer school in order to graduate with her degree plan. Therefore, she had to remain in the same city as the university, which could have limited her opportunities to work in an engineering environment. However, a local environmental agency recruited students from one of her

chemical engineering courses and she was able to secure a position with the firm. This position provided her introduction and practical experience to environmental compliance, which is an area that she returned to later in her professional career. After the summer position, Monica focused on securing a full time position during her last semester at the university.

Monica interviewed and received offers from different companies during the full time recruiting season her senior year in school. After weighing the options from a variety of companies, including telecommunications, consulting, and manufacturing, Monica accepted a chemical engineering position with an international based chemical engineering manufacturing company. The company brought her in as part of a rotational engineering program, where she worked on a different assignment every six months. She gained experience in chemical processing engineering, safety engineering, process engineering, sales, environmental engineering, and project management.

After completing four rotations, the company was not able to place her in a permanent assignment due to changes in the economy, which impacted the organization's permanent engineering assignments. Consequently, Monica looked for other job opportunities and found a position at another global chemical engineering and manufacturing company.

Monica began her career with her current organization as an environmental specialist, managing environmental regulations and compliance for plants. She enjoyed the challenges from that position and appreciated learning about the regulatory side of the business. That job, which she held for over four years, prepared her for her next role in environmental regulatory affairs. She maintained the connection to environmental regulations however she supported several sites across the United States. After a few years in that position, she moved into her current role, which is serving as the environmental health and safety support leader for five sites in her area. Monica enjoys the environmental section of the business and plans to continue developing in this area. Additionally, she was recently identified as a high potential leader for the company, which prepares such employees for future leadership positions within the company. Monica is currently assessing her career path and determining the best steps for her professional career.

Nicole

Nicole grew up in a single parent household with her mother and two older sisters. Her mother is the oldest of seven children, with five boys and two girls. Two of her uncles are engineers. Since her mother was a single parent, Nicole spent significant time with her grandmother and her uncles. During her early and elementary education years (up until junior high school), while spending time with her uncles, she helped them build model cars with motors and developed an interest in building and design, which later framed her interest in engineering. However, there were significant obstacles in place that could have deterred her from pursuing an engineering career.

Although Nicole has two older sisters, since they are four and six years older than her, she didn't really attend school with them as a child. She grew up in Central Texas in a large urban environment and is the only one in her immediate family to graduate from high school, college, and to earn an advanced degree. Her mother had to drop out of high school to help raise her brothers. Her sisters decided to drop out of high school because they had other agendas and were not focused on formal education. However, due to her mother's experiences as a result of not having a high school diploma, she stressed the importance of obtaining a good education and supported Nicole in whatever capacity to obtain a solid education. This was a primary motivating factor for Nicole to do well in school and to stay focused on education. An additional motivator for Nicole was their home environment. Nicole grew up in the government housing projects and she watched how the people in the community were comfortable

living and staying in their current circumstance and she knew that life was not for her. Nicole's environment created a passion in her to succeed and do better. She stated,

> And then just seeing my mom struggling, you know just the ends and outs, sometimes she would come home, talk about her job, the things that she had to do, the people she had to deal with and you know the attitudes. Feeling like she was not, like, a valued person at the job regardless of what her position was. You know sometimes that was frustrating for her but she realized because of her lack of education that she really felt like..[since] she didn't have an education she couldn't make a lot of noise. So just seeing that I just was like 'I don't want that for me' and when I, if I can do better, then I can pull her up out of this.

The combination of seeing her mother deal with obstacles and seeing the people in her housing complex settle for less fueled Nicole to seek and seize every opportunity for advancement.

Although Nicole's family moved regularly to different housing locations around the city, her mother ensured that her schooling was consistent. Therefore, Nicole attended one elementary school, a sixth grade center, one junior high school and one high school. Nicole described herself as a very social person and enjoyed talking to her friends and teachers. Moreover, the teachers were predominantly Caucasian in each of her schools. In fact, Nicole never had a teacher of color inside the classroom; however she developed strong relationships with her core teachers and many African American teachers outside of the classroom. She repeatedly mentioned that her teachers and other school administrators took an active interest in her and nurtured her academic

achievement and success. They nominated her for leadership and academic camps, programs, and awards, which she attended and received. Even today, she maintains relationships with teachers from her childhood and connects with them regularly.

One of her teachers, in the third grade, helped Nicole realize that she was a little different in terms of academic achievement. Her third grade teacher contacted her mother and suggested for her to be tested in order to determine if she should skip the fourth grade and be promoted from the third grade to the fifth grade. Yet, her teacher also felt that she should not actually skip the fourth grade but simply take the test to determine her level of learning. Shortly thereafter, she was placed in the advanced learning track. The school offered three different levels for the students: those who were advanced, those who were at level, and those classified as remedial learners. The school did not designate the advanced learners as honors or gifted; however, Nicole felt that her advanced track was the equivalent of those programs. Consequently, for her last two years of elementary school, Nicole participated in the accelerated learning track, specifically for mathematics and reading. The same path continued for her in junior high school.

By the time Nicole reached junior high school, the designated honors program was established and she was officially on the fast track. The school demographic was majority Hispanic students, she estimated at 70%, with 10% Caucasian, and 20% African American. However, the students in the honors program looked differently than the school demographics. There were more girls than boys, with more Caucasian girls and Nicole and her best friend as the only African American students at that level. Her

favorite subject was always mathematics because it was easy for her and she excelled; however, in middle school she began to take an interest in science. She maintained an A average in elementary and junior high school. Nicole enjoyed junior high school because in addition to excelling academically, she also was involved in extracurricular activities: she played basketball, volleyball, and ran track. Her interest in activities led her to attend a meeting one day after school, which is where she learned about the Texas Alliance for Minorities in Engineering (TAME).

Nicole received an announcement for a group meeting after school, which invited students interested in understanding how things work to attend the meeting. She was certainly interested in designing and learning and therefore attended the meeting, which was sponsored by TAME. The organization provided kinesthetic learning opportunities, which allowed the students to build and redesign tinker toys, in addition to learning about engineering and hearing speakers representing the different functional areas within engineering. Nicole was fascinated when she learned that engineers used skills that she enjoyed such as creativity, outside the box thinking, communication, mathematics and science. From that point forward, she charted her path to becoming an engineer. Her participation with TAME continued in high school.

In high school, TAME provided summer internships, field trips, preparation for college, and scholarships. Nicole continued her involvement with TAME and with other extracurricular activities like the yearbook staff, National Honor Society, track, volleyball, and basketball. Nicole knew that she was going to college upon entering high school, therefore, her plan was to maintain a high grade point average and continue

to develop in all areas. Although her first choice was to attend a large, public, predominantly White, research institution in the South, by the time she graduated she had a full scholarship to an HBCU, which she took to avoid being a financial burden on her mother. She was also invited to attend a special summer camp at her university, two weeks before her freshman year began. This camp was designated specifically for the honor students at the institution and Nicole was impressed with seeing all of the fellow African American scholars representing the top students across the nation.

Although Nicole grew up in predominantly African American neighborhoods and communities, her experience at the HBCU was eye opening. She had never experienced or seen the mass of Black people striving to better themselves, especially from an educational perspective. Growing up, she always felt like she was the only one. However, in college, she was pleasantly pleased to have peers on the same track, the same boat, and moving in the same direction. Nicole began her university career majoring in civil engineering. Her sophomore year, she switched to mechanical engineering because she liked structures, space, and aeronautics. Transitioning to college was relatively easy for Nicole and she maintained an A average in her courses. Although some of the coursework was challenging, the small class sizes, professors interest in her success, and her fellow peers in the honor program kept her focused on academic achievement and excellence. Her freshman year she was selected to attend an elite summer program called WISE, Washington Internship for Students in Engineering, and was the first HBCU student to participate in the program and the only African American for that year. When she returned from that program, a friend suggested that

she consider a major research corporation for her next internship because the organization only considered the best and the brightest in the field and her friend felt that she was a good candidate. Nicole applied and received the internship with the research organization and completed her remaining summer internships with the company.

Nicole completed a few additional summer internships with the research organization and enjoyed learning about research and development. Additionally, she liked that the company was diverse in a variety of engineering functions such as production, design, manufacturing, and development. However, upon graduating from the HBCU, Nicole decided to pursue an advanced degree and was selected as a fellow for the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM). She attended a large public, predominantly White, research institution in the South to earn her master's degree in mechanical engineering and returned to the research organization to continue her professional engineering career.

Nicole has spent all 18 years of her professional career with the same research corporation. She has held different roles and worked in different groups supporting a variety of functional areas within the organization. Initially she served as a mechanical designer for facility modifications. That was a stressful position because the design process was not updated and building specifications were not current in the system, which caused significant project delays and frustration on her end.

Shortly before leaving that group, she got pregnant and moved into a different organization within the company. In that group, her role was to manage design configurations for everything in the company. Although the position was not technically challenging, it was a good fit for her personal life at the time, which allowed her to focus on her new role as a mother. Eventually she wanted to continue sharpening her technical skills and accepted a position working as a quality engineer. This position is a good fit for her because she is constantly working on different projects and providing technical insight to many areas. However, she stated that the challenge of being the only African American in the engineering realm, and almost always the only African American female is a reality in the organization. Since there are not many who share in her identity as an African American female, she has relied on professional relationships with managers and peers for support, encouragement, and development. As a result of her educational experiences, her second career is to become a secondary teacher and encourage more students of color to pursue a technical career.

Tiffany

Initially, Tiffany thought that engineers ran trains. However, in high school she was identified as a top student and was given an exam to determine if she could participate in a pre-engineering program. She scored high on the exam, specifically in electrical engineering, and was offered a spot in the program, which was conducted in conjunction with the local university. Tiffany accepted the invitation to join the program because it seemed interesting and she thought it might lead to a scholarship or financial awards that would allow her to attend college for free. Tiffany's parents moved from the South to the Northeast to obtain better employment and opportunities for their family. Her father served in the military, retired, and secured solid employment with the county, which was a significant accomplishment for African Americans during that time. On the other hand, her mother followed a formal education journey. First, she attended a business school and later earned a master's degree, a professional degree, and served as a district administrator. Tiffany is the youngest of three sisters, one deceased, and they each earned doctoral degrees. Her parents stressed the importance of gaining a good education and consequently sent her and her sisters to private school.

Although she stated that she and her sisters were one of few African American students in the private elementary school, she remembered that the teachers were nurturing, supportive, and caring, and the school provided a solid education foundation. She took nontraditional courses, when compared to the traditional public school curriculum for elementary students. For example, her courses included French, religion, music theory, cooking, and architecture. She stated that the environment felt safe and

did not recall any incidences related to race or other negative factors either. Tiffany thought that the parental involvement, at the school overall, helped to address any problematic issues for students. After elementary school, which ended after sixth grade, Tiffany (and her sisters) moved from private to public schooling.

At the end of her elementary schooling, Tiffany's parents gave her and her sister's the option to continue attending private school, which meant they would have to fund their college education individually or attend public school, and their parents would cover the tuition for them to attend college. They selected to attend public school because they knew they were attending college and wanted to have funding secured. However, Tiffany did not enjoy the new environment in her public middle school, particularly due to the students. The demographic changed from predominantly Caucasian to majority African American with almost no Caucasian students and a few Latino students. She stated that her peers were not disciplined, they didn't respect the teachers, and the parents were not involved at the school, each of these was the exact opposite of the learning environment in her elementary school. However, she quickly found her own space by testing and placing into the advanced placement program, which continued into high school.

By joining the advanced placement program, she was connected with other students whom she felt valued education and took learning more seriously, and she enjoyed this new space. Although it was a bit competitive, she enjoyed being in a cohort with students with similar goals to pursue higher education and move into professional careers. Additionally, the pre-engineering program, in her high school, consisted of

predominantly African Americans, with the majority of the class made up of African American males. Although, the pre-engineering courses were male dominated, Tiffany did not feel that there was a distinction or negative association which favored the males over the females from the teacher or peer perspective. She felt that the culture created an equitable learning environment for everyone. Though she enjoyed the engineering courses, mathematics was her favorite subject.

In addition to being academically focused, Tiffany participated in the honor society, yearbook staff, choir, and served as the business manager for her class. However, she stated that if she had the opportunity to make one change in her secondary education it would be to get involved in a team sport. She felt that the parallels of playing a team sport to working in a corporate organization were skills that she wished she would have acquired and began to develop from an earlier age.

Tiffany knew early on that she was attending college after high school and therefore applied to three institutions of higher learning. Of the two that accepted her, she selected the large private research university in the northeastern region over the local university in her hometown. She received an incoming freshman scholarship from the institution that she selected and later earned a privately funded scholarship which covered a significant portion of her undergraduate expenses. Although the university was a predominantly White institution, they had significant resources to support students of color and assist with their success in engineering at the institution. The school provided workshops and tutorials in core content areas for all students to be successful. Additionally, the African American students were described as a closely knit

community, including the student chapter of the National Society of Black Engineers, Black Greek Letter Organizations, and other Black affiliated student organizations. Tiffany was really impressed by the scholars represented in her incoming class and the established student body and their level of support for one another. This pushed her even more to continue to excel. Initially the coursework was difficult for her to grasp; however, over time she was able to grapple the information and those moments motivated her to continue. Complementary to the engineering academic program, Tiffany joined the Society of Women Engineers (SWE), the Institute for Electrical and Electronics Engineers (IEEE), and Eta Kappa Nu, an engineering honor society.

Tiffany's university had a strong experiential learning component, which included participating in a few co-ops (with or without the same company) during her academic career. Tiffany completed several co-ops, as an undergraduate student, and was able to learn about different company cultures while gaining valuable core professional engineering experience in her field of electrical engineering.

The faculty at her institution provided support and she felt that they cared about her success. She developed strong relationships with the faculty and was fortunate to have an African American male faculty member and a female faculty member who encouraged her to pursue graduate studies and let her know that she could make it as a graduate student. Consequently, Tiffany pursued a master's degree and doctoral degree in electrical engineering at a small, public research institution in the Northeast. Additionally, the graduate school contacted her about joining their team as a doctoral student with funding for the duration of her program. The school had less than half of

the population of her undergraduate institution but that didn't stop her from moving forward into the graduate program. Also, the location of the school allowed her to stay at home with her parents, while she was a graduate student. That provided an immediate support system for her success, which she needed to obtain from her home because she was the only person of color in the graduate program. The most challenging component for her was completing the Ph.D. qualifying exam, where each student had to complete an oral component as part of the dissertation requirements. After successfully completing and passing the qualifying exam, Tiffany began working.

Initially, she accepted a position with a power company in her local area. However, after eight months in that role and feeling like there wasn't significant opportunity for professional growth and development, she decided to change industries and secured employment at a large, global technology organization. She joined the technology company 10.5 years ago and continues to work on design projects for computer hardware.

Toni

Toni was raised by her mother and her stepfather. Her biological father was not and is not a part of her life; her parents divorced when she was a baby. Her stepfather entered her life when she was around 10 years old and was a strong supporter of education and of her accomplishing her goals. Her mother and her mother's extended family were also strong supporters of education, with most of her extended family from her maternal side earning advanced degrees. Therefore, Toni knew from an early age that she was going to college, so the only questions were where she was going and what would be her major. However, before tackling college, she had to complete elementary school.

Toni attended a private school for the first few years of education and transitioned into public school in the third grade. For both schools she remembered the demographic profile consisted of African American and Hispanic students. The teachers were also mixed demographically according to race/ethnicity, however Toni remembered the she primarily had Caucasian teachers in her classes. One key memory that Toni shared was her developing fondness for mathematics at an early age. She remembered understanding the mathematics concepts and being able to process the information easily. Middle school, grades six, seventh, and eighth, presented different experiences compared to her elementary education.

In middle school, Toni moved from being at level with the core student body, to taking honors courses, which meant additional academic challenges. Her counselor realized that she was making A's and felt that she needed to be challenged more.

Therefore, she contacted her mother about moving her into the honors program. The honors program was a bit more competitive for the students, provided smaller classes for the students, and more individualized attention in the classroom. Toni still enjoyed mathematics and considered it her strongest course; however, she developed an interest in science as well. Outside of the academic environment, Toni described the middle school years as a tough transitional period. Not only did she remember dealing with the traditional adolescence challenges but the students in her school also had racial tension and physical altercations as a result. Although, there were several factors impacting her external environment, overall Toni felt that her middle school was a good experience.

The high school population was majority minority with Caucasian and Asian students representing a very small percentage of the student body. In high school, Toni was active on the debate team, played volleyball, basketball, and ran track. Toni continued to excel in the honors program and also in her mathematics skill development. She was particularly interested in geometry and that was another subject that came easy to her. She was able to visualize the images and the calculations made sense to her, whereas it was more challenging for other students to visualize and understand the guiding principles being taught in geometry. Although Toni was on the advanced honors track in high school, when she went to college she realized that maybe she was not as prepared as the other students. That's when she realized that her high school may not have had the proper resources or all of the resources for students to be able to compete at the same level in college. Consequently, Toni shared how she struggled significantly during the beginning of her college career.

Toni attended a large, public, predominantly White, research institution in the South, which was a complete culture shock for her. She had largely attended schools with significant, if not majority, minority student representation. However, at the university, she was certainly one of a small number who looked like her and an even smaller number of students represented her racial and gender identities combined in the college of engineering. Toni entered the university as a chemical engineering major and she quickly realized that the study skills that she used in high school would not help her be successful in college. She learned that she had to apply herself more and that in some areas she wasn't as prepared as others from different high schools. However, that did not deter her from pushing forward. She also had to learn to ask for assistance which was new for her; whether it was the teaching assistant, professor, or classmates. Toni felt that although the professors were available, she didn't get the sense that they were welcoming or helpful. Actually, the overall environment was not welcoming according to Toni.

In addition to the professors not creating a welcoming environment, the students in the program were also not welcoming. The population consisted of majority Caucasian males and she could count on one hand the number of African American females who were in chemical engineering. She could only remember two African American males in the chemical engineering program and they were not in her graduating class. Therefore, as she progressed in the core engineering curriculum she found it extremely difficult to find people who looked like her to study with and take courses together. Moreover, she felt that the majority population did not want her in

study groups with them and she also felt insecure joining study groups because she didn't want to feel like the only person not grasping the material. Consequently, she learned the majority of the coursework by studying alone and occasionally asking the teaching assistant. For additional resources and support, she relied on peers and programming provided by her involvement in the National Society of Black Engineers (NSBE).

Toni completed four summer internships to gain core chemical engineering experience in different companies and industries. She gained knowledge and experience in the oil and gas sector, environmental engineering, and project engineering. Each of the companies was described as having a majority Caucasian male population. However, she was able to interact with a few female engineers sprinkled into the landscape in different organizational cultures. One of the key components gained by her participation in the summer internships was the professional options and opportunities available to her with a degree in chemical engineering. It was during her second summer internship at a large national chemical corporation where she became interested in environmental engineering.

After graduating from the university, Toni accepted employment with a state environmental agency, which provided a solid foundation for her to learn about industry regulations and processes. However, after one year she moved to a global company that spans across several industries including technology, aerospace, consumer goods, and materials. The primary catalyst for the move was to receive better financial compensation. After a few years in the role, Toni wanted to relocate to a large urban

city in the South. Therefore, she accepted a position with a national leading organization in the utilities and power industry. Her first role in the company was in the air quality division. She enjoyed the nature of the job, which allowed her to work outside of the traditional cubicle office and regularly visit the power plants. Her current company also supported her obtaining the professional engineering license, which added additional responsibility and respect in her role at the company. For example, there are particular permits for bids and contracts, which require the seal from a licensed professional engineer and she is able to perform that role for the company. Consequently, she is seen as an asset to the company since they don't have to go outside of the organization and hire someone to meet those requirements for those specific projects. However, there are still challenges experienced in the professional workplace setting.

One of Toni's primary challenges is staying motivated and interested in engineering. She admitted that oftentimes she gets bored with the routine and mundane processes and procedures, which are a typical part of her professional engineering experience.

On the other hand, her company and specifically her supervisors have supported her interests in activities that support her role in the company which are not necessarily directly related to her job. For example, obtaining the professional engineering license, participating in and taking leadership roles in professional clubs that complement the company's industry, and sponsoring her current graduate studies. Toni is working on a dual graduate degree program, pursuing a master's degree in environmental management and a master of business administration. She is not sure what role she envisions herself occupying in the future, engineer or manager, however her heart is to stay in the environmental sector.

CHAPTER IV

PERSONAL AND STRUCTURAL CHALLENGES INFLUENCING THE CAREER EXPERIENCES OF AFRICAN AMERICAN FEMALE ENGINEERS

Introduction

On September 27, 2010, President Barack Obama announced an aggressive plan to improve science, technology, engineering, and mathematics, commonly referred to as STEM, education in the US. The plan focuses on improving secondary students' interest and performance in math and science areas by recruiting 10,000 STEM teachers within two years and ultimately 100,000 STEM teachers within the next 10 years. The underlying components of the initiative are as follows:

- Increasing STEM literacy so all students can think critically in science, math, engineering and technology;
- Improving the quality of math and science teaching so American students are no longer outperformed by those in other nations;
- And expanding STEM education and career opportunities for underrepresented groups, including women and minorities. (The White House, 2010, ¶3)

President Obama's STEM initiative recognizes that the intellectual capital produced by a country is linked to the innovation and advancements made in STEM as literature purports (e.g. Jackson, 2010; National Academy of Sciences, 2007; NACME, 2008; Science and Engineering Indicators, 2006). What the US manufactures and supplies as a country in these fields is the measurement of progress, innovation, and leadership.

Historically, the US has been in the forefront of STEM research and advancements (National Academy of Sciences, 2007; Science and Engineering Indicators, 2006). However, the US is currently faced with diminishing interests and advancements in STEM due to a reduction in the number of students pursuing STEM careers, a reduction in the number of STEM research projects, and a move to international markets for engineering production and manufacturing, to name a few of the challenges. This dilemma impacts the output and global leadership in a technologically-led global society (Chubin, May, & Babco, 2005; Jackson, 2010; National Academy of Sciences, 2007; Science and Engineering Indicators, 2006).

To address these issues, oftentimes the field examines the existing talent pool, as well as efforts to increase the pipeline for STEM occupations (National Academy of Sciences, 2007; NACME, 2008) particularly targeting underrepresented populations (Chubin, May, & Babco, 2005). Consequently, the bulk of literature and research addressing STEM issues concentrates on the pipeline, specifically recruitment and retention of underrepresented groups in the K-12 and collegiate realm (e.g. Gill, Sharp, Mills, & Franzway, 2008; Maton & Hrabowski, 2004; Moore, 2006; Russell, 2005). For underrepresented populations (American Indian/Alaska Natives, Blacks, Hispanics, and Pacific Islanders, for example) who manage to successfully navigate the K-12 pipeline and collegiate domains, there are additional challenges encountered in professional workplace organizations, and this study attempts to discover some of those challenges for African American female engineers.

Women of color, specifically African American women, are considerably underrepresented in engineering workplace organizations. The National Science Foundation reports that a mere 10% of the engineering workforce is characterized by underrepresented populations, namely Blacks, Hispanics, American Indian/Alaska Natives, and Pacific Islanders (Division of Science Resources Statistics, 2006e). On the other hand, women fair slightly better than racial/ethnic minorities as a group and represent 13.5% of the engineering workforce. However, African American women only account for 6% of the total number of women employed in professional engineering functions (National Science Foundation/Division of Science Resources Statistics, 2006f).

Though a small representative sample of women have made entry into engineering and found success in the engineering profession, we have very little information on these women and the factors that contribute to their experiences in the field. Additionally, there is a scarcity of research and literature examining the career experiences of African American female engineers. Therefore, the purpose of this study was to examine the career experiences of African American female engineers and, thereby, explore the personal and structural factors that served as challenges for their career progression. Specifically, the research question was: what, if any, were the challenges impacting the career experiences of African American female engineers?

The theoretical underpinning utilized to examine the career experiences of the African American women engineers was Cook, Heppner, and O'Brien's (2002) adaptation of Bronfenbrenner's (1977) ecological model. The ecological perspective, as

presented by Cook, Heppner, and O'Brien (2002, 2005) is grounded in Bronfenbrenner's work on environmental systems and the dynamic interaction that occurs between the person and the environment. He classified four environmental systems—microsystem, mesosystem, exosystem, macrosystem, and the microsystem—as key elements in human development. The microsystem consists of the individual person and interactions with the environment on a daily or frequent basis, such as school, work, and home. The mesosystem includes interactions and experiences that occur between the person's varied microsystems, for example between home and school. The exosystem includes interfaces between the person's immediate environment and external factors (e.g. school policies), which impact the person and her environment. Lastly, the macrosystem consists of the global society in which the person lives and interacts and the customs imposed on the environment. Cook, Heppner, and O'Brien propose the ecological model to frame career experiences for all women, and especially for women of color, because it creates space to recognize the gender and racial/ethnic factors that impact one's career, particularly for women and minorities.

Although acknowledging the four subsystems, Cook, Heppner, and O'Brien (2005) contend that the macro and micro system interactions are most constructive when exploring and framing career development for women of color. They stress that the macro and micro system experiences, due to race/ethnicity and gender, have a direct relationship to career intentions, pursuits, and experiences. Thus, the ecological system framed this research study by focusing on the interaction between the macro (e.g. environment, stereotypical images, political systems, and the institutional structure) and

micro (e.g. individual self-efficacy, values, and interests) subsystems to examine the career experiences of African American female engineers. The link between the need to increase diversity in STEM careers, specifically for women and people of color, and the need to understand the career experiences of these women, serve as the stimulus for examining the career experiences of African American female engineers.

Related Literature

African American women within science, technology, engineering, and mathematics (STEM) areas are significantly underrepresented in workplace organizations. Although the numbers specifically for women may show an increase in participation in STEM areas, the figures for African Americans do not reflect positive growth (Tang, 2000).

Typically, one can find a small body of research addressing one of the three distinct identities represented by the participants in this research study, namely research on African Americans, women, or engineers. However, research examining the intersection of these three identities is relatively non-existent. Furthermore, framing these identities within the context of career experiences or career development continues to limit the scope of available literature.

Therefore, in examining the literature on the topic at hand, which is also contextually framed in the literature addressing career experiences, research and literature was found that addressed the career experiences of African American engineers and the career experiences of women engineers. However, the majority of the literature focused on the experiences of White female engineers. The literature on

Blacks and other underrepresented racial groups is often included in the literature focusing on the experiences of White women (Richie, 1992), as if the experiences are equivalent. Yet, there are distinct differences as highlighted in the Catalyst (2004) report. Those differences include dealing with issues associated with stereotypical images based on race, biculturalism, and representing lower socioeconomic class status compared to other women with the same background. Nonetheless, there remains a deficit in the literature with African American female engineers at the center. Thus, the literature presented in the next section is focused on minority groups, based either on gender or race/ethnicity. Moreover, the two key areas for this body of work targets the engineering pipeline and the engineering workplace.

Engineering Pipeline

Based on the Gathering Storm Report, published by the National Academy of Sciences (2007), the pipeline is negatively impacted by inadequate science and mathematics training in the K-12 education system and minimal interest in those same disciplines in undergraduate programs and as professional careers. Reports continue to show that the number of students majoring in science and engineering programs remains stagnant or is declining (Science and Engineering Indicators 2006: S&E Trends in the United States, S&T The Global Perspective, 2006). Similarly, the data for African Americans in engineering is grim. Blacks represent 5% of all undergraduate engineering degrees earned (Engineering Workforce Commission, 2006) and Black women's representation has drastically decreased (National Science Foundation/Division of Science Resources Statistics, 2006a).

The engineering pipeline, specifically getting young students interested in math and science at an early age, is a standard component in the engineering discussion or equation (NACME, 2008; Science and Engineering Indicators, 2006) and is often reduced to an input/output function. That is to say, an increase in students interested in math and science on the front end is equal to an increase in students pursuing math and science careers on the back end. Therefore, it is not surprising that the majority of the research in this area is dedicated to factors that impact career choice (Burlew, 1982; Johnson, Stone, & Phillips, 2008; Lopez & Ann-Yi, 2006; McCowan & Alston, 1998; Moore, 2006; Perna et al., 2009). These researchers examined the correlation between self-efficacy, barriers, parental influence, cultural identity, role of the institution, and factors for specific groups, e.g. African American males, in career choice. While the research and literature centered on developing students for the engineering pipeline is a critical component in the STEM discussion, focusing solely on the pipeline is short sighted in examining the bigger issue. If the field does not address factors in workplace organizations, then the overall goal of increasing the underrepresented populations in the engineering profession may be stalled.

Engineering Workplace

Much of the literature on women in STEM careers is dedicated to retention issues for women in professional engineering arenas and focused primarily on challenges and barriers. The limited number of women and people of color in the field make it problematic, in some cases, when entering predominantly White male organizations. Rosser (2003) posited that a significant number of challenges for women engineers are a

direct result of the limited representation of women in the engineering profession. Sukumaran and Jahan (n.d.) shared a similar perspective regarding the issues women face in the workplace. They reported:

> Very few women are attracted to engineering because of gender stereotyping and discriminatory practices in the engineering workplace. The engineering profession has always been a male dominated one; hence the pervasive work culture continues to be fundamentally masculine. If the dominant metaphor for the engineering workplace is that of a leaky faucet, then the faucet is losing women at an alarming rate. (p.1)

Additionally, they noted items such as a lack of training, lack of mentors, lack of advancement or promotion, family planning issues, and sexual harassment contribute to the factors that negatively impact women in engineering. It is critical for the engineering community to address these challenges in order to increase the number of African American female engineers and women in engineering overall.

Likewise, the Catalyst (2004) report highlighted the impact of "stereotypes, visibility, and scrutiny; questioning of authority and credibility; lack of 'fit' in the workplace; double outsider status; and exclusion from informal networks" (p. 3) as barriers in the engineering workplace. Roberts and Ayre (2002) also noted the detrimental effects associated with the predominantly male environment and reported findings similar to the Catalyst (1992) report:

> Female engineers' exclusion from the "old boy network" is not unlike that of other professions. However, the small number of women in engineering

> accentuates the impact of such exclusion and leads to a feeling of isolation. More importantly, few other opportunities exist for women to learn informally across ranks and divisions. Further, there appears to be little support for formal women's networks within the workplace. (p. 4)

As a result of the challenges and barriers that women engineers face, it is not alarming that some women voluntarily leave the field. Sasser, Lineberry and Scheff (2004) highlighted factors which served as the catalyst for female engineers to pursue other options. They stated,

> Because women engineers have few role models, inadequate opportunities for mentoring, and minimal prospects for advancement, they frequently become disillusioned and leave the field, therefore reducing their numbers in the professions and, consequently, discouraging young women from considering it as a career. (p. S2H-2)

Sukumaran and Jahan (n.d.) included issues such as the need for supplementary professional training, sexual harassment/discrimination, and family commitments (i.e. balancing work/life roles, duties, and expectations) as reasons for leaving the field. Likewise, the Catalyst Report (1992) contributed to the list of barriers for women in the engineering workforce by adding the requirement for women to repeatedly demonstrate skills which limit promotion and the perception that some work environments are too rough or inappropriate for women. The barriers explaining why women leave the engineering field provide a direct relationship to the problem of retaining women of color in the engineering workplace. Despite the fact that some women leave, some

remain. Thus, the focus of this study is on those that remained in the field in an effort to identify the personal and structural challenges that influenced their career experiences as African American female engineers.

Methodology

Methodology is the framework guiding the research to gain knowledge. According to Gough (2000) "Methodology refers to a theory of producing knowledge through research and provides a rationale for the way a researcher proceeds" (p. 4). The research design and approach are grounded by the purpose of the study and according to Creswell, also by the "researcher's philosophical and theoretical stances" (2007, p. 2). This study focused on how African American female engineers made meaning of their world and their experiences holistically (Merriam, 1998, 2009). Therefore, the underlying paradigm guiding the research was basic interpretive inquiry. Merriam and Associates (2002) noted that basic interpretive inquiry is a qualitative study where the researcher seeks to understand the participant's experiences. Accordingly, "In conducting a basic qualitative study, you seek to discover and understand a phenomenon, a process, the perspectives and worldviews of the people involved, or a combination of these" (p. 6). This approach allowed me to explore the participant's lifespan and interpretations of their lived experiences. Scholars such as Creswell (2007), Merriam and Associates (2002), and Patton (2002), note several different approaches to qualitative research such as phenomenology, ethnography, grounded theory, critical theory, and case studies, to name a few; however, the basic interpretative qualitative approach most appropriately aligned with the purpose of the study.

Complementing the basic interpretive research design, life history examinations (Cole & Knowles, 2001) were employed to obtain rich data from the participants, which included exploring early life experiences that influenced their career development. With this approach, participants were encouraged to reflect on early life and school experiences and how they contributed to their career development over the lifespan. The person's storying of her life, her narrative on her life experiences are utilized and contribute to the development process (Bertaux, 1981). As Cochran (1990) noted:

> If we represent life in story, then telling stories to ourselves and others is part of life as lived. Part of career, for instance, is telling stories of the career we have had so far, have now, and want in the future. To represent a career, then, would partially involve representing the stories people construct about themselves and their life projects. (p. 73)

Individual historical representations add a rich tapestry for understanding holistically the elements that influence a person's career development as a dynamic process (Bujold, 1990) versus a snapshot in one moment of time, whether it is career choice, entry, redirection, or retirement, for example. Cole and Knowles (2001) further explained:

> Clusters of individual lives make up communities, societies, and cultures. To understand some of the complexities, complications, and confusions within the life of just one member of a community is to gain insights into the collective. In saying this we are not invoking an essentialist claim that to understand (however partially) *one* is to understand *all*. Rather, we are suggesting that every in-depth

> exploration of an individual life-in-context brings us that much closer to understanding the complexities of lives in communities. (p. 11)

Therefore, what we gain from the authors is the importance of understanding the life experience of one participant as it is significant to understanding the experiences of others. For the participants, each of the African American female engineers shares an individual narrative, which also provides insight into the experiences of others. Exploring their lives in relation to the environment gives the researcher the opportunity to pull the experiences together for a broader understanding of the contextual story as shared by the participants.

Merriam (1998) noted, "Qualitative researchers are interested in meaning—how people make sense of their lives, what they experience, how they interpret these experiences, how they structure their social worlds" (p. 19). In the same way, this study examined how the participants made meaning of their experiences, particularly those influencing their career development, as a woman and person of color. Josselson (1995) purports:

> Meaning is generated by the linkages the participant makes between aspects of her or his life as lived and by the explicit linkages the researcher makes between this understanding and interpretation, which is meaning constructed at another level of analysis. (p. 32)

The meaning the participants made between their early life experiences, educational pursuits, and workplace occurrences were valuable in understanding their experience in their totality.

In a qualitative study, the researcher becomes the primary tool for gathering data with the participants and generating knowledge (Creswell, 2007; Erlandson et al., 1993; Lincoln & Guba, 1985; Merriam, 1998, 2009; Patton, 2002). As noted by Erlandson et al. (1993), "The human instrument allows data to be collected and analyzed in an interactive process" (p. 39). The interaction between me as the researcher and the African American female engineers, contributed to the knowledge gained and allowed their voices to be captured. My goal was to obtain data "that allows for discovery rather than seeks confirmation of hypotheses and that fosters more exhaustive quests for explanation rather than the illusions of finding a preexisting truth" (Josselson, 1995, p. 30). In listening and learning from the African American female engineers as they shared multiple experiences and varied truths, I presented the knowledge gained in order to expand the dominant discourse.

Participant Selection

This research study targeted Black female engineers, working in an engineering capacity, in an engineering specific organization. Therefore, Black female engineers working in a marketing function within an engineering organization, for example, were excluded from the sample. Likewise, Black female engineers working in a sales function for a business management firm were also excluded from the study. Additionally, the participants needed to have at least 10 years of work experience as an engineer and at least one promotion, or equivalent, from an entry level position. The aforementioned tenure and promotion conditions provided a sample with experience navigating the engineering culture.

Initial participants were identified by working with professional engineering networks, for example alumnae listserv contacts. Additional participants were found by contacting engineering workplace organizations directly. In addition to these resources, snowball sampling was utilized to reach the individuals who met the criterion for the study. Table 3 provides the participant profiles, including their undergraduate college type, years in the engineering field, undergraduate engineering discipline, and current industry. The women shared many characteristics. For example, six women attended large, predominantly White undergraduate institutions (PWI) and three attended a Historically Black College or University (HBCU). They were almost equally represented by three engineering disciplines: chemical, electrical, and mechanical. Four of the participants earned graduate degrees in engineering or business. Also, the majority of the women were married with children. Each participant provided or was given a pseudonym.

Table 3
Participant Profiles

Name	Age Range	Under grad College Type	Engineering Discipline	Years in Engineering Field	Grad Degree?	Current Industry	Family Unit
Christine	36-40	Large, PWI, Public	Mechanical Engineering	10	No	Aerospace	Married, two children
Courtney	36-40	HBCU	Mechanical Engineering	10	Yes, MBA	Architectural & Design	Married, no children
Jasmine	36-40	Large, PWI, Public	Chemical Engineering	12	No	Oilfield/ Oil & Gas	Never married, no children
Josephine	41-50	Small, HBCU	Electrical Engineering	15	Yes, PhD	Technology	Divorced no children
Lisa	30-35	Large, PWI, private	Chemical Engineering	10	No	Oilfield/Oil & Gas	Married, no children
Monica	30-35	Large, PWI, private	Chemical Engineering	11	No	Chemical Manufacturing	Married, one child
Nicole	41-50	HBCU	Mechanical Engineering	18	Yes, MS	Research	Married, two children
Tiffany	41-50	Large, PWI, private	Electrical Engineering	12	Yes, PhD	Technology	Married, one child
Toni	30-35	Large, PWI, private	Chemical Engineering	12	No	Utilities and Power	Married, two children

Due to the varied career paths, it is significant to note that although this research study included African American female engineers who received at least one promotion, or equivalent, from an entry level position, they were not expected to be in a managerial

position. Moreover, this study did not include African American female engineers whose current position was in senior management or above. The reason for this exclusion was to focus on African American female engineers serving in engineering functions, rather than high level leadership positions. This is important because one of the goals of this study is to inform the engineering community (e.g. K-12, higher education, and workplace organizations) about possible factors to consider in recruiting and retaining African American women in core engineering professional roles.

Data Collection

Data was obtained primarily using in-depth interviewing employing a general interview guide approach (Patton, 2002). The general interview guide approach provided some structure to ensure that specific content was addressed during each interview; however, there was freedom in the sequence of the questions, which allowed for a more conversational design, resembling Cole and Knowles (2001) description of a guided conversation. Accordingly, "The questions were deliberately open-ended and based on the principle of 'less is more' in the belief that broad, open questions that help frame an issue or event or circumstance, and allow wide latitude in responses, yield rich insights" (p. 73). The interview guide was constructed using the life history approach (Cole & Knowles, 2001), Cook, Heppner, and O'Brien's (2005) ecological framework, and other bodies of related literature. These items informed the topics that were addressed during the interview including family structure and background, secondary education, higher education, and workplace environment. This style of interviewing supported building

rapport with interviewees and relied on the interaction and environment created between me as the researcher and the interviewee to discover data.

The first interviews lasted between 90-150 minutes and delved into the participants' life history and career experiences. They took place at a location designated as a natural environment (Creswell, 2007; Patton, 2002) by the participant, for example, the participant's home, office, or a public library. Follow up interviews were conducted to address specific experiences and points of clarification, as needed. Individual interviews were digitally recorded with permission, and transcribed verbatim.

Data Analysis

Creswell (2007) describes the qualitative analysis process as a data analysis spiral, which denotes the nonlinear and dynamic form of the analysis process. This process begins with multiple readings of the text to gain a comprehensive understanding of the data. Subsequently, the data is examined in smaller units for individual participant understanding. As a result, the data was analyzed in three phases: first, a case story was created; second, a thematic analysis was conducted for each case; and third, cross cases analysis was completed for common themes.

Phase One – Case Story. Initially, each interview required several readings of the text to gain a deeper understanding of the interviewee (Cole & Knowles, 2001). This process assisted in creating a case story for each participant, which was sent to the participant for member checking. The case story provides an overview of the participant and the factors which contributed to her academic and professional experiences as an African American female. The goal was to paint a portrait of the developmental

experiences leading to and including the experiences in the engineering workplace. The case story for each participant is in the last section of this chapter.

Phase Two – Thematic Analysis. In the second phase of data analysis, the transcribed interviews were examined as individual units of data. Following Creswell's (2007) approach to data management, each complete transcript was organized into units of data in Microsoft Word and printed on index cards. The cards were used to develop initial categories and each individual life story was categorized based on chronological events (e.g. elementary education, college experiences, and workplace setting). Once the interviews were aligned chronologically, a thematic analysis was conducted for each narrative (Riessman, 2008). Thematic analysis focuses on the content of the narrative (Riessman, 2008) in order to identify commonalities and differences amongst themes in the data. This was an iterative process as noted by Creswell, "This process consists of moving from the reading and memoing loop into the spiral to the describing, classifying, and interpreting loop" (p. 151). The themes were identified according to significant incidences in the participant's story (e.g. initial introduction to engineering, challenges, support systems, and sacrifices).

Phase Three – Cross Case Analysis. After the themes were identified for each narrative, then a cross case analysis was completed to capture similarities in the themes. The common themes across each of the cases were examined to identify common factors and differences in the findings. Lastly, once the common themes were identified the findings were organized as either a microsystem (individual) component or a macrosystem (environmental) component.

Data Trustworthiness

Qualitative researchers address data trustworthiness in order for the reader to assess if the findings are credible (Erlandson et al., 1993). Creswell (2007) further noted the importance of the qualitative researcher, as the primary tool for gathering data, in providing and following mechanisms which strengthen the dependability of the research. Therefore, the strategies used to demonstrate data trustworthiness in the data included member checking, peer debriefing, and thick descriptions.

Member Checking. Member checking provides the participant with the opportunity to review the data before and during analysis for an accurate understanding of the information gathered (Creswell, 2007; Patton, 2002). Member checks were utilized during the first phase of the data analysis process. The participants were emailed their transcript from the interview to review and edit as needed. Only one participant elected to make changes to the transcript and the edits were primarily on correcting spellings for company names referenced during the interview. Additionally, the participants received the case story for review and again only grammatical changes were made.

Peer Debriefing. Peer debriefing was another strategy employed to ensure data trustworthiness (Erlandson et al., 1993; Patton, 2002). According to Erlandson et al. peer debriefing sessions can be informal discussions with colleagues and peers. As such, I met with professors and peers to discuss the findings and data analysis. These debriefings included conversations regarding the process used, noted findings, and expected findings, which were not found. While reviewing and analyzing the data, this

strategy challenged me as the researcher to remain engaged with the details and open to all discoveries.

Thick Descriptions. An additional strategy, commonly utilized in qualitative research is the use of thick descriptions in presenting the data. As Patton (2002) noted, these detailed descriptions add to the data trustworthiness by providing the reader with contextual information and a richer understanding of the findings. The narratives included in the findings provide thick descriptions, which assist the reader with understanding the totality of the experience.

Findings

The findings in this section are taken from a larger study exploring the factors impacting the career experiences of African American female engineers. The research question which guided the study, as presented in this section, is: what, if any, were the macrosystem (i.e. environmental) and microsystem (i.e. internal or personal) challenges influencing the career experiences of African American female engineers? For purposes of this study, the microsystem is defined by the individual person and the macrosystem is characterized by factors external to the individual. The scope of these systems is supported by Cook, Heppner, and O'Brien's (2005) adaptation of the ecological model. In analyzing the data from the nine African American female engineers, the findings were grouped into two key areas: the college experience and the professional workplace setting. Although data was provided representing early childhood experiences and K-12 learning experiences, these items were not identified as challenges by the participants. The findings for each category are presented in the next section.

College Experience

Within the college environment, the participants shared experiences that further segmented their challenges into two distinct spaces: individual factors and characteristics at the collegiate level and the university atmosphere. The components discovered in each space are detailed below.

Individual Factors. The women reflected on their collegiate experiences and shared the following individual factors, which served as challenges during their collegiate career: (a) lacking discipline and focus, (b) difficulty seeking assistance, and (c) adjusting to the program rigor.

Lacking Discipline and Focus. Whether it was getting involved in a sorority or being too involved in outside classroom activities, the participants shared a similar sentiment when it came to a point in time during their college career when there was a lack of focus. Christine noted that coming into the university setting, she was not mentally ready for the amount of work required for success; she had not disciplined herself accordingly. She stated:

> I didn't make very good grades the first semester, but I put my scholarship in jeopardy and my mom was like, "well, did you really do your best?" And my answer was "no, not really," and she knows me. I was up playing dominoes all night; that's what I did! And I really wasn't studying. I thought it was enough, but I would miss class and, so, I just was not very disciplined going in.

Similarly, Monica highlighted a lack of focus during her sophomore year of college. During that time, she was more focused on extracurricular activities with her sorority than on the academic workload in her engineering classes. She shared:

> Then I pledged my sorority. So, second semester of my sophomore year, I wasn't really focused on my coursework. And then the first semester of my junior year, I was new to my sorority, so I wasn't really focused on my coursework.

Demands placed on her due to her affiliation with the sorority provided an additional area to lose focus on school. Nevertheless, Monica accepted personal responsibility in prioritizing her activities. She added:

> My biggest challenge was probably just my own focus and you know, you could get off track with. . .pledging. . .the sorority, boys, drama with boys. . .just that focus was probably my biggest struggle. (Because) if I focused and put my mind to it, then I could do it, but, you know, you are just doing other stuff.

Therefore, Monica knew that she was capable of doing the work; however she needed to remain disciplined. Likewise, Lisa shared the challenges she experienced with balancing school and outside of class activities. She stated:

> I was doing good and then the junior year, I got a little bit more social and so. . .things became much more of a challenge, but looking back on it was a challenge because of choices that I made in regard to how I spent my time. And so I think that's when it got difficult for me, and there were some classes that I dropped.

Lisa's personal development in time management paralleled Courtney's learning for prioritizing. Courtney shared how her independence as a college student impacted her

focus on school. She noted, "maturing in my freedom, moving off campus, all that stuff, you know, and started to experience a little sink in that GPA." Personal actions which negatively impacted the women's grade point average provided the needed awakening for the women to get back on track academically. Ultimately, they experienced challenging times while transitioning from high school to college. The independence and freedom as a college student, lack of focus, difficulty balancing school and outside activities, were all factors that negatively impacted their college experiences. Although the women found themselves losing focus while attending to their studies, seeking assistance became an additional challenge for them.

Difficulty Seeking Assistance. Learning to ask for help was an attribute that developed in order for the young Black female students to be successful in their academic career. In their previous learning environments, the women were consistently successful in their academic pursuits. However, inevitably they hit a wall at some point during their college career and had to seek assistance outside of their own capabilities. Tiffany shared:

> I actually had to apply myself more and seek out help where needed. That was new for me too. . .to come out of my shell and ask the TA. [To admit] that I need[ed] help on something or ask other students where there were study sessions or something like that, you know, "hey let's get together and study." . . . I think that took a different maturity, and. . .I grew into that eventually but, yeah, it was an experience.

Likewise, Jasmine shared her perspective regarding learning how to seek assistance. Initially, she told herself, "I don't need no tutor; what do I need a tutor for? You know, I should be able to do this on my own." Eventually Jasmine realized that it was acceptable to ask for assistance. Toni's perspective was in the same vein regarding seeking assistance. However, it was directed toward working in a group. Toni often felt like she was the only person who did not understand the material and, therefore, did not want to seek assistance with a study group. She rationalized, "I didn't want to slow down their progress. So if they had to continuously stop and tell me this is how you do it. . . I didn't want to be a hindrance to their study group. So, I was like, I will figure it out on my own." For these women, this was the first time where they struggled to learn material and felt challenged academically. Therefore, learning to ask for assistance was difficult for them. Ultimately, the women learned how to seek assistance from peers, professors, and teaching assistants as they formed networks centered on academic success.

Adjusting to the Program Rigor. Although, the women largely participated in honors, talented and gifted, and/or advanced placement courses, in addition to attending, in some cases, private or magnet high schools, they still felt that they were not prepared for the college engineering curriculum. The participants shared how the engineering curriculum was difficult and felt that they were not adequately prepared in high school for the rigors of the collegiate program.

Jasmine shared her difficulty in understanding chemistry sequence courses at the beginning of her core engineering course curriculum. She stated:

> My first engineering core class, one was Organic Chemistry, and I ended up not doing well in Organic Chemistry, and I dropped the class. And I remember I took it in the summer time, I did horrible in the summer time and I, you know, you're so frustrated because you're like 'this is my first true semester of engineering and I can't grasp it!'

Jasmine highlighted the annoyance shared by many of the participants when an engineering subject was challenging to understand. Toni also noted her struggles with the early college coursework and the surprise that occurred when transitioning from easily mastering the material in high school. The frustration was compounded when she reflected on the ease with which she mastered the high school curriculum. She shared:

> And I struggled with that, because like I said, coming from high school, being an 'A' student and graduating two in my class, it was a wakeup call. I was just like, I'm not used to this, not being able to get it! And so, it was a big struggle!

Tiffany, another participant, reflected on the difficulty of the engineering program as well. She stated, "it was really hard too, you know I had my hard times and my crying and all that, just trying to adjust." The difficult times expressed by the participants were significant, yet the women persevered. Monica concurred by sharing how the coursework was progressively more difficult for her to comprehend. She added:

> And that was hard for me to deal with just because I had never really experienced that. Even like if I would study, I still didn't get it. So that was kind of difficult to deal with. And I think. . .sometimes I would just be like I'm not studying. . . I

think I got some C's in those classes. So all of that was kind of new and disappointing.

Adjusting to the rigor of the program was challenging for these women because, in most cases, this was their first experience with not knowing the answers, with not being able to grasp the information easily and quickly, and with learning how to ask for assistance from others. As Toni said, "I thought I would just. . .be able to get it. I got it in high school, I could just be able to get it where. . .it didn't happen that way." Nevertheless, the women persevered and learned how to navigate the academic challenges presented by the rigor of the engineering curriculum and the demands of the program.

In this section, I presented the three individual or microsystem factors that served as challenges to the participants: lacking discipline and focus, difficulty seeking assistance, and adjusting to the program rigor. For each of these themes, the participants experienced these factors for the first time in the collegiate realm. Although these factors were challenges for the individual participants, the women were able to navigate their individual system and develop the skills needed to persist in their undergraduate engineering program. However, individual factors only presented one area of challenge; colleges and universities provided environmental or institutional challenges for the participants.

Institutional Factors. As young college-aged African American females, the participants recalled significant challenges which resulted from the campus climate. The majority of the participants attended a predominantly White institution (PWI) for their

undergraduate engineering degree. However, even for the participants who attended a historically Black college or university (HBCU) for their undergraduate degree, they attended a PWI for their graduate degree and shared similar experiences as the others. The factors presented as challenges at the institutional level included: (a) limited African American female representation, (b) uncaring and unsupportive professors, and (c) an unwelcoming peer network.

Limited African American Female Representation. The participants often noted the lack of diversity in the engineering programs in their college or university. The women stated there was a limited number of women and people of color overall and specifically the minimal numbers representing African Americans and African American women in their engineering programs. Lisa shared that her classmates were typically international students or White males in the electrical engineering program at her large, private, PWI. Therefore, she was often the only female and only Black student in the class. Josephine, who majored in engineering at an elite White university added, "I was the only Black the whole time I was there, and I was there four years. In that department I was the only Black, male or female there." Jasmine shared experiences similar to the others and also noted the transition from being in a minority-majority secondary education system to a completely different experience in terms of gender and racial representation. In regards to the sheer number of students of color and/or women in her engineering program, she commented:

> There wasn't enough of. . .you didn't see you present, and so who do you talk to? You know, who do you communicate with? Your instructors are not you, your

> instructors are not even mostly Caucasian, they're maybe Indian, Asian, and I guess it goes back to your demographics. If you're surrounded in an area where it's always been you and then you come to this whole place and it's like a melting pot, and now my instructors are people who I can't identify with, you know, some people were having real issues with that.

The limited representation, from a gender and racial perspective, had a strong impact on the participant's experience within the environment. Although the women adjusted and learned how to navigate the space, it was an environment where additional representation was preferred and could have provided additional support for the African American female students.

*Uncaring and Unsupportive Professors***.** Regardless of institution type, PWI or HBCU, the participants perceived that professors were uncaring and unsupportive of their success in the engineering program. After the participants were asked if they felt that their professors cared about their success as a Black female student in the engineering program they were asked a follow-up question, which addressed if their professor's reaction was applicable to all students, or reserved for students of color, women, or some other factor of exclusion/inclusion.

One participant, Lisa, felt that the engineering professors were not particularly caring towards students in general in the engineering program. She stated that there was only one professor during her college career that showed interest in her success as a student. Her sentiment regarding professor care and concern was shared with the following:

> I think that was a general feeling against all students. However, I also feel like if someone fit a certain profile, I'm sure the professor probably would you know, maybe give that person a little bit more attention maybe, but overall I would say that was true.

As a follow-up question to her statement above, she was asked to describe the profile that she felt generated interest from professors, and she stated:

> Profile being, maybe, the son of someone who is important. Maybe someone who, internships are really big, and, so, maybe someone who had a certain internship with a certain company. That's a way in for [some professors] and I didn't know that at the time, but that's a way in for the professor to maybe get funding for some kind of project that they have. And so those type of connections, you know, I didn't have because my parents were not in oil and gas or a part of anything like that, to where they would have any particular interest.

Therefore, being part of the oil and gas network provided access and privilege for some students. However, Courtney stated that she never experienced a connection with an engineering professor and matter of factly stated that was just the nature of the environment. At her HBCU, the class size was no more than 50 students and she stated, "but I can't say that there was any teacher that specifically said, you know, "c'mon girl, get it together,". . . I can't remember having that type of connection with a teacher."

On the other hand, Monica attended a large, PWI and stated that she felt that her mathematics professors took an interest in her as a student and showed care and concern about her success. Conversely, she felt that her engineering professors did not care

about her success as a student. When asked if she felt that they didn't care about her and other women and people of color alike, or did she feel that was the treatment for all students regardless of race, gender, or other social constructs, she replied:

> Well at the time, I thought it was [the same treatment for everyone], but now at work, I work with people that graduated from (the university) around the same time that I did and they're all like 'oh yea, professor so and so. . .and he did this and you know we, we used to hang out with him' and I'm like 'what!' I had no idea. So now as I look back on it I think that other people had a different experience than I did.

Moreover, she noted that all of her engineering professors were White men except one professor who was Asian. The women were certainly challenged by interacting with professors who expressed limited, if any, care or concern in their success as an engineering student at their respective institutions. Consequently, they looked to other sources for support and assistance.

Unwelcoming Peer Network. Due to their racial identity as African American, and their gender identity as women, the participants felt that they were often excluded or not invited into certain spaces by their peers. This dynamic manifested during classes when the students had to form study groups and oftentimes, as Black females, they felt isolated and excluded. This dynamic also occurred outside of the class setting, which is why the participants largely preferred joining the racially/ethnically affiliated and communal engineering organizations like the National Society of Black Engineers

versus the typically predominantly White professional student engineering organizations for their particular major (e.g. Institute of Electrical and Electronics Engineers-IEEE).

Josephine used the word "hostile" to describe how she felt when her peers did not welcome her into the academic environment. She declared:

> It was hostile. I don't use that word lightly but, for me, the environment at (the elite White institution) was hostile. Let me give you an example: at (the university) you don't do a thesis, at that time. It was all coursework right. And so most of the coursework you had to work in teams, so it was a team of people, you worked together on a project, which was a significant part of your grade. And so, every class I took, that required work in teams, which was just about every class. The first day of class is when you, at the end of class, you get together and form your team. And so the first quarter after every class I had people who. . . I would come to them and have a conversation you know to see if I could be a part of their team. They would look at me from head to toe and shake their head no, including the women.

Josephine's experience notes the rejection she felt by her peers in the classroom and by her peers overall. It was challenging for her to connect with majority population: White students, male and female. However, this feeling was not limited to the classroom; it was also experienced in the student organizations.

Jasmine described the professional engineering organizations as all-White male organizations, and for that reason, organizations where she didn't belong. She noted, "AICHE (American Institute of Chemical Engineers) was a good old boy social network

and. . .when you go, everything was about a party and. . .they're doing things that's not me, my culture. I just couldn't relate to an entire group. I didn't feel a part of it." Also, the White dominated student organizations seemed to have access to additional resources which the Black organizations did not have the same access. Nicole highlighted the discrepancy between the predominantly White professional student organizations and the Black students as:

> They have this thing they called the bible for (the PWI) where it's basically a whole bunch of old tests from professors. And that's what the White kids have always had. That's what all the fraternities do; they have all those old tests. Whereas Black people hadn't gotten smart yet. Because at (the HBCU), we didn't have any bible. We tried to start it but you gotta have an organization that's gonna keep up with the stuff because the people are going to leave.

Therefore, being excluded from the majority White peer network meant that one was also excluded from privileged resources. Perhaps, the limited access to the network was a result of stereotypical images.

Lisa attended a large PWI and described her perspective on the impact of stereotypes in the college classroom, particularly in engineering. This viewpoint could provide the backdrop for the hostile environment as described by Josephine and a rationale for the limited resources as described by Nicole. Lisa shared:

> If you look at the stereotypes, when you get into the class, first day of the class and you look around the Black female is probably not the person that people are gonna say, "oh she's probably very smart and she is going to do well in this

> class." The Hispanic guy, you know, people are not gonna look at him and say, "oh yeah, I'm gonna be his study partner." People were looking for, at that time, the Asian students, and partly because the Asian students seem to have a camaraderie; they seem to have a community about themselves to where you knew that student had previous notes from somebody else who had taken the class… Their group was a group that supported each other and helped one another. And I think the Black students. . .did that as well but. . .we were such a small group that, in some cases, there may simply have been no one who took your class within the past couple of years to where they could really offer stuff that would be relevant to you.

The network for the African American women was severely limited and restricted by their White male peers in the engineering program. They felt unplugged from and unable to access the resources given to and shared by the majority population. Consequently, the women developed their own networks to support their success as young African American female engineering students. Despite the challenges in the college environment, they completed their undergraduate degree and found employment in high profile organizations and began their professional careers.

Professional Workplace

The participants shared significant challenges as African American female engineers in predominantly White male engineering organizations. These challenges began in their early career and continue, to a lesser degree, in the present workplace setting. The dominant subthemes emergent as challenges within this category include:

(a) the lack of diversity within engineering organizations, and (b) the impact of the participants' age, race, and gender on their career experiences. Of these two subthemes, the later is the most descriptive and ideally would be presented as three independent sections: age, race, and gender. However, for the most part, the participants shared narratives that included all three components. There were limited cases where one of the variables—age, race, or gender—was presented as the dominant identifiable challenge and those cases are presented accordingly. The findings addressing the limited diversity are presented initially.

Lack of Diversity in the Organization. The participants noted that they were extremely aware of their identity as Black female engineers because there were so few Blacks and women represented in the field and specifically within their engineering organization. Courtney described how the distribution looked in her company, specifically in regards to the number of African American female engineers. She stated, "First of all, there were two of us. . . There were probably four hundred in the entire company. I would say probably, at least two hundred were architects, the other two hundred may have been engineers; there were two of us." Courtney's description of the architectural and design organization and her lived experience, representing one of two African American female engineers, served as a frequent reminder of her minority status in the workplace setting. Jasmine shared related experiences working in predominantly White male organizations in the oil and gas industry. Her incidences with the lack of diversity went beyond race and included gender and age. She highlighted:

> All of them were older; they were much, much older. It's truly an age gap similar to what we see today that existed back then. I will tell you from a minority standpoint, for both of the companies I worked for, to be in the engineering field, there were no African Americans. In the refinery, the African Americans were typically operators or they worked in the personnel group.

Being the only African American female engineer in the refinery meant that she had to learn quickly how to navigate the workplace with professional White males, as well as with paraprofessional Black males. Her developmental understanding of the workplace was also influenced by the generational differences in employees, due to age gaps. Josephine provided an additional perspective regarding the limited number of females in the corporate research sector of her high tech company. She stated, "Now I can also say that I was in research for 12 years and in those 12 years there was no other Black woman research staff member." Therefore, Josephine served as the only female engineer of color for her organization during her entire tenure in research and development. Consequently, when she left that sector of the organization for a temporary assignment in another area, she never returned. The job assignment in the other sector of the organization had more women to include women of color.

Not only did participants note the lack of racial and gender diversity at their level within the organization, they also noted that there was limited diversity or representation of women and people of color in high level leadership positions. Monica described what she noticed while working for an international company in the oil and gas industry. She shared:

> They did not have any diversity programs, and I actually told them this when I left. The uncertainty was the main reason that I left but. . .they were just doing like a diversity survey. They had not done anything on diversity; they didn't have any goals around diversity, [and] there were no women in leadership. I can count on my hands the number of women who were in leadership positions.

Nicole shared a similar outlook regarding her company and its diversity. She stated:

> We are a company that still does not have an African American vice president and the company is 50 plus years. We have not had a vice president that is African American. They made it as far as to Director which is right up under a VP, but we have never had an African American vice president.

Due to a lack of racial and gender diversity in the engineering profession, the participants quickly understood that they would not see many, if any, people in their organization who looked liked them or identified as an African American female. As Jasmine stated, "I think [one thing] we still continue to face, is not enough females, and it's definitely not enough African American females." Consequently, it was important for the African American women to connect with other women and people of color in the organization and to develop alliances with the other underrepresented professionals for support in navigating the predominantly White male organizations.

Participant's Age, Race, and Gender. The participants shared challenges associated with their identity based on their age, race, or gender, and a combination of all three identifiers. They experienced difficult encounters with managers, non-engineering support personnel, and their colleagues. In most cases, the interactions of

all three variables was presented; however, in the descriptions below, the participant's age was the dominant factor.

Impact of Age. Transitioning from a recent college graduate to a professional engineer provided challenges for the women as they entered organizations with older engineering professionals. Lisa shared the complication of being a young engineer when she graduated from college and entered her first professional job in an oil and gas company. She highlighted one of her challenging experiences:

> Definitely good old boy system there, and not until I started having management type of responsibility did I really get push back. Previous to that, it was kind of like, yeah, we'll help you and that type thing, but when it became a situation where a young twenty something was a manager and had authority over them, then that's when there were issues.

Toni also worked in the oil and gas industry and felt similar challenges as a result of her age. She stated, "I think some people tend to say, well you are young. . .so, for people who have been operating in the plant for 40 years [they say], 'who are you young buck?'" There was a negative impact of age, as the participants transitioned from recent undergraduate college students to engineering professionals, especially when members of the engineering workplace were significantly older. Jasmine stated her challenges regarding age, specifically having to look a certain age to be credible and taken seriously in the workplace environment. She declared:

> And so when we come to the table, you know, sometimes we're not taken as seriously…because there's such a huge age gap; . . .and so they figure, how can

> you speak when you don't have enough experience? You know, "when did you come in?" You know, "what do you know?" So when I come to the table. . .first thing people think is, "oh, she's in personnel." Or, some people thought, "oh, I thought you were an administrative assistant." Because. . .they think most women, that's where they come from. And when you sit back and you tell them, "no, I come from operations. I've been working for this long." First thing (they typically say is), "you don't look that old." And I'm like, "how old am I supposed to look?" I mean, "Are you supposed to look old?"

The participants were challenged by their age in the engineering workplace, when perceived to represent a younger age by the older White men. As young professional engineers they felt that they had to prove themselves, their engineering capabilities, and learn how to stand firm. They were not seen as credible because of the the view that age is synonymous to knowledge and experience and therefore not viewed as competent. As a result, a young-looking engineer is perceived to lack knowledge and experience and, hence, by virtue of her young age lack competentency. Nevertheless, they persevered, only in some cases, to address or deal with additional challenges associated with their gender.

Impact of Gender. Oftentimes, the African American female engineers stated that their gender was a more significant challenge than their race, in terms of opposition from the White male network. Furthermore, they shared feelings as if they were not connected to the male network or that they were excluded from the network. When asked about situations where she felt excluded or challenged, Courtney stated, "I think it

was primarily because I was female. Nobody said anything out of the way to me about race, so I can't attribute it to being Black female, but definitely because I was female." Likewise, Jasmine recalled a situation where the person in charge of an oil rig did not want her there simply because she was a woman and he did not want women contaminating his all male workplace environment. She described:

> And so at the time because I was female, I go on location and the guy didn't have a problem with me being Black; he had a problem with. . .(as he stated), "(Jasmine) I don't want you to do work on my job," and I said, "why," he said, "because women are a distraction to me and my men on the rigs. And I don't have women working on my rigs."

Ultimately, Jasmine began and completed the project on the rig while the client sought a male engineer for the job. After she finished the assignment, the client was pleased with her work and requested her for additional jobs, which she declined. The participants' gender, in some cases had stronger negative consequences and implications than their race/ethnicity in the workplace. Nevertheless, the challenges associated with the intersection or combination of factors—age, race, and gender—represented the dominant challenges.

Impact of Age, Race, and Gender. Several participants described organizational workplaces as unreceptive, hostile, and/or challenging environments. Christine learned about her organization's culture during an internship experience in the aerospace industry. She received firsthand experience of the unwelcoming environment for Black women. She recalled:

> You have these older men in engineering who. . .weren't very used to seeing women in engineering, let alone Black women. And, I could see that was an issue; that's not something that they were accustomed to. . . A few of them would make comments like "yeah, you know, I don't know if you are going to make it". . . . It was crazy, but I was more determined. . . I'm going to school, and I'm working hard and what do you mean to tell me "I'm not going to make it." Not something to tell a student. . .but, I'm a fighter.

Christine's experience as a summer intern gave her insight into the challenges that she might face as a professional engineer. Accordingly, as African American female engineers entering predominantly White male organization, the environment played a demanding role in their experiences. Toni worked in the utilities and power industry and shared:

> I think initially, early on in my career, when I would go out and visit the plants, it's a different environment. Coming in. . .number one as a female, but as an African American female and talking to plant operators, they may say 'who are you and, why are you here?'

As a result of the limited numbers of Blacks, females, or both identifiers represented in professional positions in engineering organizations, the participants often had to address or deal with assumptions from colleagues, on a regular basis. Working in the research industry, Nicole recalled assumptions she's dealt with during a cross functional team meeting:

> Challenge wise it's really being able to break that barrier. . .we still have a glass barrier for African Americans and in particular for African American women. . . So that's the barrier that I've had to break and I've gotten there now because now people know who I am, they know the level of education that I have, they know the level of experience that I have, so they know when I come in, I'm an engineer. . . But before. . .when they saw me, they automatically assumed that I was the person that was going to be capturing the notes from the meeting minutes. . . Nope, wrong person. . .and it's like that because I'm usually the only African American sitting in the room. Every now and then there may be an African American male but the females; African American technical females in the labs are very low.

In addition to the experiences in team meetings and other office interactions, sometimes the unwelcoming working environment manifested during social activities after work. These informal incidences and networks often excluded the Black female engineers. As Lisa shared:

> Our particular entity is very small and so the good old boy system is at play and even more so on the social side with dinner or drinks after work. Or, you know, one guy is from the east coast and he has a beach home and he invited the guy to come with him for the weekend. They were going to go fishing or whatever. So, again that's not something that I would be able to participate in right? So, it's not so much that I would say that guy excluded me from doing it, but it wouldn't be

> something that would be appropriate for me to spend the weekend with him fishing.

These often overlooked systems of exclusion served as challenges for the participants, particularly as they sought to develop networks to advance their careers. On the other hand, unfortunately, there were also occasions where the participants shared stories of experiencing blatant racism and sexism. Jasmine recalled an experience as a young Black female chemical engineer and new professional. Oftentimes, in her role, she went to remote locations and worked in small rural areas in the US. She stated:

> I just couldn't even believe they're people who still exist in the US who act like this. And my operator who worked for me, he was just so bitter and he was like, "only reason you got your job cause you," he said, "because you're a woman." Not only that, "you're a nigger woman and that's why you work here and you gone still be working here when I probably don't got no job because you're a nigger woman." I said, "really?" you know, so I'm taken aback, and that really kind of hurt my feelings, and I remember I went home and cried, and I never called home and told nobody. So every day he had something just rude to say.

This situation was shocking to Jasmine because the racism was blatant as compared to the subtle forms of racism and discrimination shared by women of color in predominantly White organizations. Due to this situation, Jasmine wanted to leave the company and possibly the engineering field altogether. However, her support system provided the necessary motivation to continue and endure the hostile environment.

The impact of age, race, and gender provided significant challenges in the

engineering workplace. Josephine worked in a research environment for a global technology company and noted the similarities in the industry research environment and general hostility as well. She stated, "They challenge your thoughts, they challenge what you do, and in many instances for engineering because it's all male or overwhelmingly male at that time, they do it in a hostile way." Although her experience and description specifically addressed the corporate research culture, many of the participants shared similar perspectives, regardless of the industry type. Representing one of few professionals who shared a similar identity, whether it was race, gender, or age, was a significant challenge for the African American female engineers and, in most cases, is still an issue in the engineering workplace.

Discussion

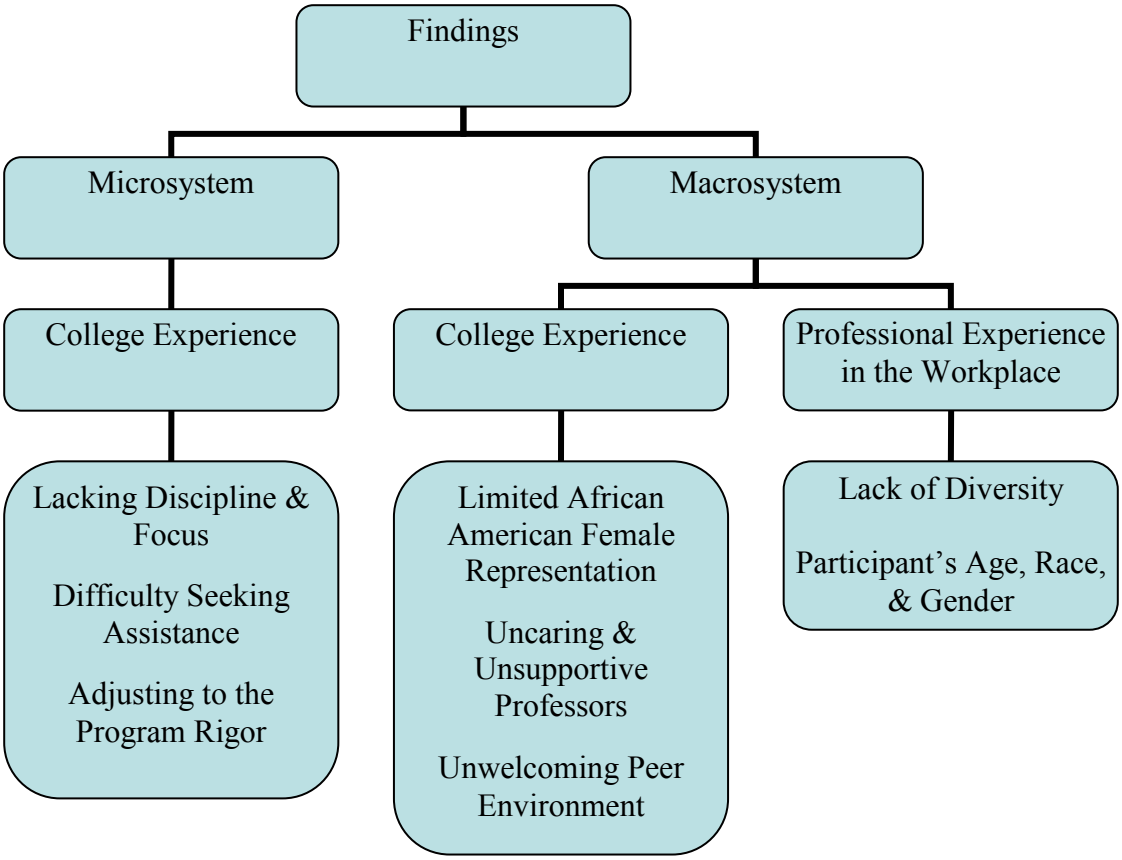
The purpose of the study was to investigate the challenges impacting the career experiences of African American female engineers. The theoretical framework guiding the study focused on examining the data from an ecological perspective, namely the microsystem and macrosystem factors that posed challenges to career development. The microsystem describes elements that are focused on the individual in which the locus of control rests with the person.

The macrosystem factors are elements that influence and impact the participant in the environment; however, the person may not have responsibility or direct control over those factors. The themes that emerged from the data were categorized into two primary areas in the lives of the participants: their collegiate experiences and their experiences in the professional engineering workplace. The microsystem factors presented by the participants were primarily during their college experiences. Microsystem factors included lacking discipline and focus, difficulty seeking assistance, and adjusting to the program rigor. Figure 3 provides a graphical representation of the categories and the findings.

Their collegiate experiences also included macrosystem challenges, which were limited African American female representation, uncaring and unsupportive professors, and an unwelcoming peer network. Similarly, the data that emerged from their experiences in the professional engineering workplace were categorized as macrosystem factors. Those factors included a lack of diversity in the organization and the participant's age, race, and gender. The discussion begins with the microsystem factors.

Figure 3

Graphical Representation of the Research Findings: Personal and Structural Challenges



Individual Challenges to Career Development

Microsystem factors included a lack of discipline and focus, difficulty seeking assistance, and adjusting to the program rigor. The participants shared difficult transitions from high school to college as young Black women aspiring to become engineering professionals. In the literature, two of the subthemes—lacking discipline

and focus and adjusting to the program rigor—appeared to connect. For example, students entered undergraduate engineering programs with a high degree of self-confidence and unrealistic expectations of the required workload. This reality check, in turn caused the students to conduct a self evaluation. Consequently, if the student persisted, then they became focused and established a more disciplined academic lifestyle. Etzkowitz, Kemelgo, and Uzzi (2000) noted:

> Most women enter college in the U.S. at a peak of self-confidence, based on good high school performances, good scores in their Scholastic Aptitude Tests, and a great deal of encouragement and praise from teachers, family and friends. Soon after entry into college, women who felt intelligent, were confident in their abilities and prior performance level, and took their sense of identity for granted, began to feel isolated, insecure, intimidated; to question whether they 'belonged' in the sciences at all, and whether they were good enough to continue. (p. 59)

The African American women in the study were no different. They entered their undergraduate institution with high self confidence, strong mathematics and science backgrounds, and a plan to graduate with an engineering degree. However, they also hit the virtual wall at some point during their academic career, which was due to a combination of individual factors such as incorrectly prioritizing social activities and not focusing on their studies, in addition to learning how to learn and study in the engineering environment.

Goodman et al. (2002) noted that engineering students complained that they had substantially more work than their peers in other disciplines, which did not afford them

time to participate in activities outside of the academic program. Although the participants were able to participate in extracurricular activities, they realized that they had to prioritize differently than their peers and may not be allowed as much time to socialize outside of engineering. Conversely, Goodman et al. noted that women leave engineering because they could not handle the academic environment in engineering. Moreover, they reported that female engineers typically struggle with the engineering demands in academia because they often experience this challenge for the first time as an undergraduate college student. Although the participants in the study had similar experiences in terms of their grades being negatively impacted at some point during their college career, they were determined to be successful and their academic goals were not disrupted. The participants knew that they could perform better scholastically than a semester or two with low grades and eventually proved it to themselves.

One factor that served to be significant in terms of navigating the academic requirements for engineering was learning to seek assistance. Although Brainard and Carlin (1997) reported that women who learn to work independently are more likely to persist in engineering programs, Goodman et al. (2002) stressed the importance of students working together, in study groups, for academic assistance and success.

The participants in the study represented both sides of the pendulum. Toni shared her desire to work alone because she did not want to slow down the group's progress. Therefore, she found it easier to work independently or seek individual assistance from the teaching assistant. Other participants in the study eventually learned

that they studied best with a group of students, typically other African American engineering students who provided support and challenged them at the same time.

Whether studying in groups or studying alone, an underlying trait that impeded the African American students was learning to ask for help overall. Learning to ask for help appeared to be an individual trait that was significantly underutilized by the participants. This could be explained by research that reports women have decreasing or minimal self-confidence when compared to their male counterparts (Goodman et al., 2002). Consequently, women are more timid when seeking assistance from others. However, examining interpersonal traits without including the impact and climate of the environment presents a one-sided view of the system. That is to say, the environment may have provided barriers for the participants' difficulty seeking assistance.

Collegiate Challenges to Career Development

The engineering environment, at the institutional level, severely lacked racial and gender diversity, as described by the African American female engineers. This meant that they were keenly aware of their status as the only person of color and/or woman in the engineering classroom, in their area of specialization, or in other spaces focused on core engineering. This finding is consistent with Goodman et al.'s (2002) report, which states that women take notice of the lack of females in engineering programs, as faculty, and as professional engineers in the workplace.

To address the lack of women and racial minorities, Busch-Vishniac and Jarosz, (2004) suggest that one area, which has not been addressed or significantly researched but that can provide a space to explore and make gains in getting more diversity in the

field is in the content or engineering curriculum. The authors state that with a few changes to the content presented in the courses, undergraduate engineering programs may recruit more women and students of color to pursue the field. They noted:

> There is certainly ample evidence that the undergraduate student population in engineering is not terribly diverse, with the situation worsening in spite of ongoing attempts at improvement. As stated up front, we believe that a revolutionary change is needed—one that addresses the root cause: an unattractive, unresponsive, and culturally biased curriculum—rather than an easing of symptoms through numerical targets achieved by any means possible. (p. 276)

The authors propose that by making changes to the curriculum, such as including the people tied to the concepts in engineering, including a social component that addresses the communities represented by women and people of color, and by adding explicit multicultural and diversity material in the classroom, engineering programs will gain more diversity. Busch-Vishniac and Jarosz (2004) agree that there needs to be curricular changes in engineering, which are currently designed with a bias towards White males.

They also suggest curricular changes, which include an increased relational approach to engineering where the content is connected to the student, particularly for women and students of color, and to the larger society. In essence, explaining how what is being taught in the classroom benefits the larger society would attract those who desire a sense of connecting and giving back to the community. However, curricular changes are not changed in a vacuum; in order to impact change in engineering content,

one has to address the additional challenge presented by those who teach in the engineering classroom.

The African American female participants shared a common experience in the classroom: they felt that the professors did not take an interest in their success as a student. The uncaring and unsupportive professors served as a challenge for the participants. Perhaps the challenge is due to the difference in gender, as the participants noted. As cited by Farrell (2002), the typical engineering faculty member is male, representing 95% of the faculty population. Complementary to gender difference, Astin and Astin (1993) reported that faculty in major universities tend to focus on research more than teaching. These faculty members classically use teaching-centered pedagogical techniques (e.g. lecturing) instead of student-centered approaches. Combining this method of teaching with inequitable treatment in the classroom (Colbeck, Cabrera, and Terenzini, 2001) led the participants to feel that professors were uncaring and unsupportive of their learning and success. Therefore, a limited approach to teaching combined with an emphasis on research negatively impacts the classroom and college environment for all students, and especially for the African American female students who have other negative factors contributing to the environment and adding to the unwelcoming setting.

Colbeck, Cabrera, and Terenzini (2001) found in their research on faculty teaching and classroom environment that the underlying perception was that male students typically responded to and treated females differently than males. Similarly, Etzkowitz, Kemelgo, and Uzzi (2000) determined that "Many men are well aware that

they or their peers often exclude the women in their classes from their working or social groups solely because they are women" (p. 60). Consequently, although Goodman et al. (2002) reported how study groups are valuable and almost a needed resource in engineering college programs, the unwelcoming milieu makes it even more difficult for the African American women in class to connect and form alliances with classmates who are not interested in working with women and people of color. The participants experienced firsthand the feeling of being treated differently due to their gender and race.

In addition to the hostile environment which resulted from gender differences in the classroom, the African American women also had to deal with issues based on race. According to The College Board (1999):

> Because White students are still a large majority on most campuses, the negative views of some Whites can contribute to a perception that minorities are "unwelcome." Although hard to measure, this "lack of hospitality," as one member of the Task Force puts it, appears to undermine the academic performance of many minority students. (p. 16)

While the participants did not directly state that the environment impacted their academic performance, they did note how the unwelcoming peer environment presented challenges and obstacles in supporting their success. Goodman et al. (2002) noted how the environmental challenges are problematic, particularly for women:

> Research on why women leave engineering has focused on either large, societal factors that have an impact on women and the engineering culture, or on

> women's experiences as individuals in the engineering milieu. However, these theories are interrelated: the societal factors that shape women's concepts and expectations of themselves in engineering affect engineering schools, including faculty and administrators. The "gendered" nature of science and engineering affects the individual, her self confidence, her preparation in high school, her experience with machines and technology, and her concept of engineering, as well as the institution, its curriculum, its pedagogy, and its theories of engineering. (p. 14)

The participants shared common factors as presented by Goodman et al., at the individual and institutional level. The women noted their academic unpreparedness for college, unsupportive faculty, and peer challenges due to race and gender. As a result of the varying factors at different times in the academic lifespan, it is important to examine the interaction of elements in a common thread. Therefore, the discussion on challenges impacting the career experiences of African American females has to include the professional workplace setting and the macrosystem factors at that level.

Workplace Challenges to Career Development

Analogous to the challenges due to limited African American female representation in the collegiate environment, the same lack of diversity carried over into the workplace setting. It makes sense that a lack of diversity in the pipeline would extend to a lack of diversity in the professional workplace setting. The engineering community continues to note the unsatisfactory numbers for minorities in the field, yet as Watson and Froyd (2007) noted, diversity goals remain unmet. Although literature

(e.g. Catalyst, 1992; Rosser, 2003; Sukumaran & Jahan, n.d.) in the field includes a multitude of challenges such as few mentors, balance of work and family, and sexual harassment, to name a few, the participants primarily shared challenges related to gender and the intersection of gender, race, and age.

There is limited research on the challenges in the engineering workplace associated with age, whether younger or older, and the intersection of this factor with race and gender (Gill, Sharp, Mills, & Franzway, 2008; Roberts & Ayre, 2002). Moreover, literature in the field often highlights the experiences of White women; the challenges incurred by women of color are often overlooked (Richie, 1992). The experiences by White women and women of color are not synonymous, as noted in the Catalyst (2004) report. One distinguishing factor highlighted in the report stated, "Whereas White women frequently reference the 'glass ceiling' as blocking their advancement up the career ladder, women of color often characterize the barriers they encounter as comprising a 'concrete ceiling'—one that is more dense and less easily shattered" (p.3). One participant explicitly referenced the glass ceiling as a barrier in the workplace and the others, although not explicitly stated, were aware that there were few, if any, African American women in positions that matched their career goals specifically and in leadership positions overall. Therefore, some participants relied on connections with White women, who served as mentors and coaches, for career guidance.

The Catalyst (2004) report also noted how African American women felt excluded from the professional network, due to their race and gender, which was consistent with the findings from the study. Miller's (2004) research on women

engineers in the oil industry highlighted the importance of informal networks to the career progression for women in engineering. That is why the limited access to networks in the male dominated structure was problematic for the women of color. McIlwee and Robinson (1992) researched the impact of gender in the workplace and found that men respond negatively to professional women in the workplace culture and especially those in male dominated fields. They stated:

> As a result, men feel threatened, invaded, and uncomfortable. They react with hostility, subtle or overt, and try to reassert their superiority. They tease, belittle, insult, ignore. They respond with skepticism to women's contributions, or patronize them as "cute little things" who need their help. They assign them tasks that fit their own images of "women's work." They exclude women from casual conversations around the coffee machine, at lunch, or after work. At worst, they engage in outright harassment, sexual or otherwise. (p. 95)

Challenges presented by the participants included exclusion, racism, sexism, and general harsh treatment as defined by the participant. These factors parallel findings presented in research and literature, which addresses barriers and challenges for women (e.g. Catalyst, 1992, 2004; Gill, Sharp, Mills, & Franzway, 2008; McIlwee & Robinson, 1992; Miller, 2004; Roberts & Ayre, 2002; Robinson & McIlwee, 1991) and provide several points to address for workplace organizations seeking to retain African American women in engineering organizations.

The Catalyst (1992) report noted that many of the challenges experienced by female engineers is common in other professions, however the exclusion of females

from the network in engineering is more harmful. Until the challenges, as presented by the African American female engineers, are addressed by organizations then the environment, as experienced by the participants, will remain relatively unchanged. The underlying assumption felt in predominantly male engineering organizations is, "To be taken as an engineer is to look like an engineer, talk like an engineer, and act like an engineer. In most workplaces this means looking, talking, and acting male" (Robinson & McIlwee, 1991, p. 406). The African American female engineers shared feelings related to this assumption and noted the challenges associated with confronting this norm and expectation.

Conclusion

Using Cook, Heppner, and O'Brien (2002) ecological framework, the African American female engineers shared challenging factors in the microsystem (i.e. lacking discipline and focus, difficulty seeking assistance, and adjusting to the program rigor) and macrosystem (i.e. unwelcoming and unsupportive professors, unwelcoming peer network, limited African American female representation, and impact of age, race, and gender). As Cook, Heppner, and O'Brien highlighted, it was imperative to note the participants interaction with the environment, specifically focusing on gendered and racial experiences. The findings in this study provide such an analysis with a critical eye towards the interaction component of the systems in the environment. That is to say, it is difficult to analyze the microsystem components, which served as challenges for the women without considering the larger context (i.e. macrosystem). Therefore, the

influence and impact of the macrosystem served as an umbrella for the experiences that occurred at the individual (microsystem) level.

In analyzing the individual and environmental challenges for these Black women engineers, one may recognize experiences commonly shared by White women and in some cases Black men. However, Black women are marginalized by race and gender whereas the aforementioned groups encounter one or the other. Therefore, the interaction within the system, should it allow privilege at any given time, grants it to Black women engineers at the lowest level. Their struggles with racism, sexism, and ageism, in addition to intrapersonal conflict and peer isolation are uniquely shared as Black women. What we learn from this group is the dynamic interaction between these Black female engineers and the environment, which provides insight into the variables of consideration. Moreover, any significant attempt to increase representation in STEM, by Black women, will need to consider the interrelationship of the system versus a compartmentalized approach.

This research adds pertinent data to understanding the career experiences of African American females and the challenges faced on their journey. Moreover, it is important to study African American women as an individual group because "Women of color (African-American, Latinas, and Asian women) are clearly not a monolithic group. The personal and professional profiles of the African-American women research participants are quite different from those of Latinas and Asian women" (Catalyst, 2004, p. 3). There are opportunities for change to occur in the system, which could positively impact the career—academic and professional workplace—experiences of African American female engineers. As stated by John Brooks Slaughter, President and CEO, NACME, "We must pursue an agenda for change that removes barriers and builds bridges to opportunities for underrepresented minorities" (NACME, 2008, p. 7). For if we, in the engineering community, do not take this charge as an important action item on our agenda then we are failing the future global leaders in engineering and technology.

CHAPTER V

PERSONAL AND STRUCTURAL ELEMENTS OF SUPPORT FOR AFRICAN AMERICAN FEMALE ENGINEERS

> The solution to America's competitiveness problem lies in bringing young underrepresented minorities into STEM careers in dramatically increased numbers. The diversity of background, talent, and thought that they will bring to the sciences and engineering is our only hope of maintaining our country's traditional lead in technological innovation.
>
> Nick Donofrio, Executive Vice President of Innovation and Technology for IBM, NACME/AAAS Roundtable. (NACME, 2008, p.4)

Research in science, technology, engineering, and mathematics, commonly referred to as STEM, is a top priority for organizations across the board. This is due to the fact that traditionally the STEM fields set the benchmarks for assessing and comparing intellectual capital per country (Science and Engineering Indicators, 2006), and this focus trickles down to corporations, institutions, and education systems alike. Characteristically, the intellectual capital produced by a country is connected to the innovation and advancements made in STEM (Jackson, 2010; National Academy of Sciences, 2007; NACME, 2008; Science and Engineering Indicators, 2006). Therefore, the US production and contribution, as a country, in these fields, is a key measurement of progress, innovation, and leadership. Historically, the US leads the race in STEM research and advancements (National Academy of Sciences, 2007; Science and

Engineering Indicators, 2006). However, the shrinking talent pool is often noted as one of the challenges, which threaten the US stance as a global leader in STEM (National Academy of Sciences, 2007; NACME, 2008; Science and Engineering Indicators, 2006).

The dialogue surrounding the talent pool is typically centered on recruitment and retention in the K-12 and higher education domains and the associated challenges (e.g. Farrell, 2002; National Academy of Sciences, 2007). One of the primary factors impacting the STEM pipeline is the lack of students interested in mathematics and science courses at the K-12 education levels (NACME, 2008; Science and Engineering Indicators, 2006), which negatively impacts the number of students majoring in STEM disciplines at the collegiate level and pursuing STEM careers. Additionally, the Gathering Storm Report, published by the National Academy of Sciences (2007), noted the following factors as challenges for the talent pool:

> K–12 student preparation in science and mathematics, limited undergraduate interest in science and engineering majors, significant student attrition among science and engineering undergraduate and graduate students, and science and engineering education that in some instances inadequately prepares students to work outside universities. (p. 121)

Although the recruitment and retention issues are significant topics for the STEM field, there is a need to address the factors that contribute to success for students in STEM in order to better learn from the students who were retained by the field. Addressing the systems of support are especially crucial for underrepresented populations—women and

people of color—as those are the groups often targeted, yet who remain a minority in the STEM professions.

In order to increase the enrollment numbers in STEM disciplines, one traditional area of focus is to target and recruit underrepresented populations, which includes women and people of color. At a NACME roundtable, Nick Donofrio, Executive Vice President of Innovation and Technology for IBM, stressed the importance of diversity in the STEM fields in stating, "We are going to run out of talent unless we get more women and underrepresented minorities going to college to study STEM" (as cited in NACME, 2008, p. 4). Nick further noted, "Other countries are going to outnumber us in graduating engineers, but we need diversity of thought and innovation to stay ahead. We need women and minorities, or we have a bleak future" (p. 4). Increasing gender and racial/ethnic representation in STEM fields, generally and in leadership, is paramount to future success in the US and globally.

The preponderance of literature and research addressing underrepresented populations (American Indian/Alaska Natives, Blacks, Hispanics, and Pacific Islanders) in STEM issues is focused on the K-12 and collegiate pipeline (e.g. Gill, Sharp, Mills, & Franzway, 2008; Maton & Hrabowski, 2004; Moore, 2006; National Academy of Sciences, 2007; Russell, 2005; and Vogt, Hocevar, & Hagedorn, 2007). There is little information regarding those who manage to successfully navigate the K-12 pipeline and collegiate domains and find success in professional workplace organizations. Although there is a focus on minorities in STEM, there is a dearth of research and literature examining the career experiences of African American female engineers. Therefore, the

purpose of this study was to examine the career experiences of African American female engineers and particularly to understand the personal and structural factors which contributed to their support system. The research question guiding the study was: what, if any, were the systems of support impacting the career experiences of African American female engineers?

To examine the career experiences of the African American women engineers, Cook, Heppner, and O'Brien (2005) adaptation of Bronfenbrenner's (1977) ecological model was used as the theoretical framework for the study. The ecological model, as presented by Cook, Heppner, and O'Brien, centers race/ethnicity and gender as key components of career experiences for racial/ethnic minorities and women. Cook, Heppner, and O'Brien (2002) ecological perspective is rooted in Bronfenbrenner's (1977) systems theory, which highlights the influence of the person's interaction with the environment. There are four subsystems in Bronfenbrenner's model: macrosystem, exosystem, mesosystem, and the microsystem. The microsystem includes the person and her interactions, which occur on a frequent basis such as home and school. The mesosystem consists of interactions between the person's microsystems. The exosystem consists of external actions, which impact the person and her environment. The macrosystem includes the larger global community and norms and customs that are dictated as part of the environment.

While recognizing the four subsystems in Bronfenbrenner's model, Cook, Heppner, and O'Brien (2005) assert that the interactions at the microsystem and macrosystem levels are most valuable for analyzing the career experiences for women of

color. The rationale for focusing on these two subsystems is due to the impact of racial and gender experiences at these levels and the corresponding relationship on career progression. Therefore, the ecological framework for this study focuses on the relationship between the microsystem (defined as individual/personal factors) and the macrosystem (defined as factors external to the individual) as both elements impact the career experiences of African American female engineers. The need to comprehend the career experiences for African American women combined with the goal to increase diversity in STEM careers, served as the catalyst for examining the career experiences of African American female engineers.

Related Literature

A dominant discussion in the STEM field is centered on increasing the number of students at the elementary, secondary, and collegiate education levels to consider careers in science, engineering, and other technical fields. Moreover, the majority of the empirical research, whether qualitatively or quantitatively designed, is focused on factors impacting career choice. This discussion is core for all students, understandably heightened for students of color, and certainly for Black female youth. Consequently, researchers attempt to answer the core question surrounding how students select STEM fields, what impacts their decision, and factors that can be addressed to positively impact students considering STEM fields. Although the research in this section is focused on career choice, there were different variables for consideration. The quantitative research covered the role of self efficacy (Lopez & Ann-Yi, 2006; Johnson, Stone, and Phillips, 2008), barriers (Lopez & Ann-Yi, 2006), parental influence (Burlew, 1982), and cultural

identity (McCowan & Alston, 1998). The qualitative research examined the role of the institution (Perna et al., 2009) and factors considered by African American males (Moore, 2006).

Lopez and Ann-Yi (2006) surveyed 359 female college students at a Southwestern urban university, which consisted of a diverse racial/ethnic representation and varied academic classification. The purpose was to understand differences in the impact of self efficacy and barriers (experienced or perceived) on career choice in relationship to race/ethnicity. They hypothesized that Hispanic and African American women would report a lower self-efficacy and more barriers regarding career indecision when compared to White women. Their findings were contrary to their hypothesis in that they "found no significant between-racial/ethnic-group differences with respect to currently experienced educational barriers, barrier-related coping beliefs, or career decision-making self-efficacy scores" (p. 41). Although African American women were more likely to have higher perceptions of barriers compared to the other groups, essentially, the authors found there was no distinction based on race/ethnicity for the group's approach to career choice. According to this research, the perception of barriers for African American female college students could influence their decision to pursue a career in the STEM field and present an initial challenge possibly before entering college. Therefore, the perception of barriers should be addressed when dealing with college students and developing strategies to recruit African American females to the engineering field.

Similar to Lopez and Ann-Yi's (2006) research on career choice, Johnson, Stone, and Phillips (2008) conducted a study to examine the relationship between race, gender, and self-efficacy for African American and female students in the information technology (IT) pipeline. The researchers used quantitative methods by surveying 256 undergraduate students identified as Black or White, male or female. They hypothesized that women and African Americans would have a lower IT self-efficacy than their White male counterparts. However, the findings revealed the opposite. Black students had higher IT self-efficacy than White students, and women reported lower IT self-efficacy levels than men. Since Black students reported a higher IT self-efficacy, the authors noted that there must be a stronger determining factor (besides self-efficacy) for Black students' career choice and specifically for selecting IT as a career. The authors concluded that self-efficacy was not the most important factor and offered "a number of factors other than self-efficacy—including perceived discrimination, lack of similar role models, and differences in cultural values—may preclude African Americans from pursuing careers in IT" (p. 1015). Based on these findings, the engineering community gained insight into possible challenges that could negatively impact the engineering pipeline in academia and in the professional workplace. Increasing role models for African American women and creating a supportive climate will assist this group in pursuing a career in technology. In examining the research, including Black women in STEM, a dominant theme was career choice.

Another body of work found relevant to research is that of Burlew (1982). While focused on career choice, Burlew's research differs from the aforementioned studies

because her study centered on Black females and added the nontraditional career component. Burlew surveyed 147 Black female undergraduate students to understand the relationship of family role models, environment, and expectations on career choice, and to compare data regarding those who selected nontraditional career paths versus traditional paths. She hypothesized that Black women pursuing nontraditional careers had a higher self-concept than those pursuing traditional careers. The literature (e.g., Burlew, 1982; Burlew & Johnson, 1992) referencing nontraditional and traditional terms typically identify nontraditional careers as those fields occupied predominantly by men, which includes the STEM disciplines. On the other hand, traditional careers are predominantly occupied by women, for example nursing, education, and social work. In the study, Burlew (1982) found that the role of the mother and her education and career background had a positive influence in women seeking nontraditional career fields. Additionally, she found that Black females were more likely to select nontraditional careers if they had previous work history. Although the research is dated from the 1980's, the issues presented and found have relevance for understanding today's women's career choice and development. For example, Burlew noted that women, specifically African American women, earned less than men, pursued low wage jobs, and were needed in larger numbers in the STEM fields. An additional parallel with her research included the notion that studies on African American women and factors addressing their career development were scant.

Like Burlew (1982), McCowan and Alston (1998) researched African American women and their career choice. However, they also added the role of identity to the list

of factors influencing career decision. McCowan and Alston sought to "examine the relationship among racial identity, African self-consciousness, and career decidedness in first-year and senior women in both historically Black and predominantly White college environments" (p. 28). The authors surveyed 212 African American students at two comparable institutions: one Historically Black College (HBCU) and one predominantly White college (PWCU). The researchers hypothesized that the senior level students at both institutions would have a higher level of insight into their racial identity and career choice. Their findings revealed that the racial identity variable had a stronger association for the senior women at the HBCU than at the PWCU. However, in terms of career choice, they found that the senior women at the PWCU were more confident in their career choice than the women at the HBCU. The implications provided were targeted for college career counselors to help them advise female students of color in their career choice and to consider how their racial/ethnic and cultural identity development may be a factor (whether minimal or not) in their career decision and in their overall identity development. This research sheds light on the importance of the college environment to the college career decision making process, as an external factor, and the association of racial identity, as an internal factor, for young African American female engineering students. The external setting and the internal disposition can serve as challenges for African American female engineers or serve as systems of support.

McCowan and Alston (1998) emphasized the importance of the environment on career choice for African American women and Perna et al. (2009) focused on the environmental factors at a predominantly African American female college with a high

success rate for graduating Black female students in the STEM fields. The researchers completed a qualitative case study to examine how one HBCU, Spellman College, contributed to and supported African American female students pursuing careers in the STEM disciplines. The authors interviewed 19 students (focus groups), three faculty members, and five administrators for data collection. Perna et al. found four themes in their research related to Spellman's support of Black women pursuing STEM fields: (a) the schools rich legacy positively impacts Black women in STEM, (b) the institution supports the student's solid foundation and future goals, as related to STEM areas, (c) there is a general understanding of the barriers and challenges for Black women pursuing STEM fields, and (d) as a counter to the third finding listed, the institution has systems in place to address the challenges and barriers that Black women face in STEM fields. The study revealed that the combination of these elements provides the support and success structure needed to retain and graduate Black female students in STEM.

While Perna et al.'s (2009) study focused on women, Moore (2006) examined factors which contribute to African American males pursuing and remaining in STEM disciplines during college. Moore completed a qualitative study by interviewing 42 African American male, junior and senior, engineering students. The following factors were considered prominent in determining the academic and professional path:

> (a) strong interests in science, technology, engineering, and mathematics; (b) strong familial influence and encouragement; (c) strong aptitudes in science and mathematics; (d) meaningful academic experiences and relationships with school

> personnel; and (e) meaningful enrichment programs, opportunities, and academic experiences. (p. 250)

Based on the findings, Moore provided suggestions for secondary education personnel and parents to identify and support students inclined to consider STEM areas. Although the population is not an exact match (according to gender and student variability), the information gained from the research findings adds value to understanding the general dialogue concerning STEM and career factors among African Americans.

The empirical research in this area, although scattered in terms of focus, share some common elements. All of the research was focused on career choice at the collegiate level. Research focusing on the factors influencing career choice for students is valuable in understanding career development for Black females holistically. Additionally, this body of research provides contextual information regarding the influence of background and early academic career factors for the study of African American women in engineering. An additional commonality within this body of research is that there appears to be a minimal relationship between race/ethnicity and career choice. Furthermore, the body of research in this category posits that environmental factors including parental roles, institution, and supporting staff (personally and professionally) are valid constructs for Black women considering STEM fields.

Moreover, the majority of research pertaining to women and racial/ethnic minorities in STEM is concentrated on increasing the pipeline, career choice, recruitment/barriers, and retention of underrepresented groups in the K-12 and collegiate

domain (e.g. Burlew, 1982; Johnson, Stone, & Phillips, 2008; Lopez & Ann-Yi, 2006; Moore, 2006; and Perna et al., 2009). Often, in the research and literature, the experiences of racial/ethnic minority engineers are grouped into the same categorical experiences as women, and this discounts the role that race plays in career development. There is little, if any, literature specifically focused on the career development or experiences of African American female engineers, which could provide the missing link in the discussion centered on creating positive change for diversity in STEM.

The empirical research in this area, although scattered in terms of focus, share common elements. All of the research was focused on career choice at the collegiate level. Research focusing on the factors impacting career choice for students is valuable in understanding career development for Black females holistically and provides contextual information regarding support systems, specifically the influence of background and early academic career factors. Moreover, the research in this category concur that environmental factors including parental roles, institution, and supporting staff (personally and professionally) are valid constructs for Black women considering STEM fields.

Methodology

This section provides an overview of the research design and methodology. For a detailed description of the research design, see Chapter IV. The purpose of this study was to understand the career experiences of African American female engineers. Therefore, basic interpretive inquiry guided this study, using a life history approach (Cole & Knowles, 2001). The life history approach allowed the participants to reveal

factors from early childhood experiences, K-12, college, and the professional workplace setting.

Participant Selection

Black female engineers were the targeted group for this study. The factors for inclusion were that the women needed at least 10 years of experience as an engineer, at least one promotion, and currently working in an engineering capacity for an engineering organization. These requirements were utilized to obtain a sample with sustained experience in the engineering workplace. Participants were identified using professional listservs and contacting engineering corporations directly. Additionally, snowball sampling was utilized. Participant profiles are included in Table 4. The women were closely divided by three disciplines: chemical, mechanical, and electrical. The majority of the women attended large, predominantly White institutions (PWI) and were married with children. Some of the participants elected to earn graduate degrees. Each participant has a pseudonym.

Table 4
Participant Profile Summary

Name	Age Range	Under grad College Type	Engineering Discipline	Years in Engineering Field	Grad Degree?	Current Industry	Family Unit
Christine	36-40	Large, PWI, Public	Mechanical Engineering	10	No	Aerospace	Married, two children
Courtney	36-40	HBCU	Mechanical Engineering	10	Yes, MBA	Architectural & Design	Married, no children
Jasmine	36-40	Large, PWI, Public	Chemical Engineering	12	No	Oilfield/ Oil & Gas	Never married, no children
Josephine	41-50	Small, HBCU	Electrical Engineering	15	Yes, PhD	Technology	Divorced no children
Lisa	30-35	Large, PWI, private	Chemical Engineering	10	No	Oilfield/Oil & Gas	Married, no children
Monica	30-35	Large, PWI, private	Chemical Engineering	11	No	Chemical Manufacturing	Married, one child
Nicole	41-50	HBCU	Mechanical Engineering	18	Yes, MS	Research	Married, two children
Tiffany	41-50	Large, PWI, private	Electrical Engineering	12	Yes, PhD	Technology	Married, one child
Toni	30-35	Large, PWI, private	Chemical Engineering	12	No	Utilities and Power	Married, two children

Data Collection and Analysis

Patton's (2002) general interview guide approach was used to conduct in-depth interviewing. The interviews took place at locations deemed convenient and appropriate by the participants. The first round of interviewing took between 90 and 150 minutes. The second round of interviewing was conducted to address follow-up questions or clarify initial points of information. Each interview was digitally recorded and transcribed verbatim, with permission.

There were three phases to the data analysis: first, a case story was produced; second, a thematic analysis was utilized for each case; and third, cross cases analysis was conducted to synthesize themes. I used the following strategies to ensure data trustworthiness: member checking, peer briefing, and thick descriptions.

Findings

In this section, I present data from a larger study that examined the career experiences of African American female engineers. The research question which guided the study is: what, if any, were the macrosystem (external environment) and microsystem (individual) factors contributing to the support system in the career experiences of the African American female engineers? Using the ecological framework, the data revealed microsystem and macrosystem factors at the individual level, family structure, K-12, higher education, and professional workplace settings. The findings within each category are presented accordingly.

Microsystem Perspectives of Support

There were two common factors presented by the participants at the individual level: self-image and determination and persistence. The dynamic of these factors is detailed below.

Self-Image. The role of self-image included how the women felt about their abilities in mathematics and science and their confidence in these areas. The women in the study remembered having a strong affinity towards mathematics in particular, and in some cases, also for science from an early age. Toni recalled her experience with mathematics, she stated,

> I definitely remember liking math. I can definitely say that. The thinking that was required even at that elementary level, I just remember getting it and even probably earlier on, like in elementary school when you talk about multiplication tables or addition and subtraction, I just got it. Shapes and all of that, it just clicked with me. So I would probably have to say math was probably my strongest area.

Courtney also remembered early childhood experiences where she connected with mathematics and engineering mechanics. She recalled,

> Well, I was naturally mechanically inclined. Obviously I didn't know it, but I think my mother, after the fact, saw it. You know, I would do things like when I was 8, the washing machine was broken, and I took the cords off the washing machine and replaced the cords and you know, stuff like that. [Doing things

> that] a typical 8 year old wouldn't do. . . I liked it; it was a natural fit; [and I] was good at math. . . It was just a natural fit.

Having a strong inclination for math, combined with a curious stance for understanding how things worked in the home, led to a positive self-image in early education. The same sentiments regarding math in elementary education carried over into junior high and high school for the participants. Monica shared her accomplishment in high school, stating,

> I was very good in calculus. I got the calculus award, you know like the senior award, [and I received] the chemistry II award. . .it just clicked. I was very good in those classes, and I liked those classes. . . I was always good in math and science.

In addition to the women excelling in mathematics and science courses, they were affirmed by others regarding their academic capabilities. Nicole received words of affirmation from her mother. She shared,

> And I think all of that goes back to my mom telling me how I was going to be this great person one day. . . and. . .it starts in the home. If you don't get that in the home, I think it's a lot harder. I still think that you can do it, but I think that if you don't have people at home telling you how smart you are, or how you can do it, or you can do anything you put your mind to, I think it's just a little bit harder because you don't have that internal support that you should have. All children should have it; doesn't matter if it's a single parent or a two parent.

Nicole's verbal support from her mother provided the necessary motivation when she experienced difficult times academically and professionally. Encouragement from family, friends, and other supporters provides critical contributions to the women's self-image. Likewise, Christine received words of affirmation from a friend of the family who she later identified as her role model in engineering. She stated that seeing an African American engineer, someone who looked like her, motivated her to explore the field. When referring to her role model she stated, "So he was just very positive and letting me know that I could do it and that kind of thing. So that is how I got interested in it." His positive influence made a lasting impact on Christine. She added,

> Because my role model had really said I could do engineering, and don't worry about being a woman, and you're going to do well; I just had in my mind. . .even before attending this magnet [high] school, I just had this thing in my mind that I was going to be an engineer.

Words of affirmation, which nurtured their self-image as aspiring African American female engineers, were powerful for the participants. The constructive vocal support, combined with their positive internal association and connection to the mathematics and science curriculum in the classroom, proved to create strong self-images and provided powerful support structures for the participants.

Determination and Perseverance. One of the underlying mantra's guiding the women was that quitting was not an option, and they adopted a spirit of determination and perseverance. The participants shared stories explicitly stating that they were not going to quit or change their academic plan because they felt destined to become

engineers. That is not to say that they did not have obstacles, challenges, or barriers that made them ponder the option to quit. In the end, however, they inherently knew that they could not quit the journey on the path to becoming an engineer. Monica shared her viewpoint in this vein, in stating that she knew somehow she would survive the challenges of being in the engineering program in college:

> [The] motivating factor was just, I never even thought about quitting because I knew I would get through it, but I never thought about switching my major or anything like that. That didn't seem to be an option to me. . . You know those folks that were in the same classes with me, that were kind of going through it with me. I don't know, I just never really even thought about like switching my major because I just figured I would get through it.

Although Monica didn't know how she would make it through the program, ultimately, she knew that she would persevere. Similarly, Lisa thought about alternative paths to reaching her goal of becoming an engineer, while in college, yet decided to stay in the program:

> I did think about it and looked into it. Not quitting in like dropping out of school but, looking at other options of how I can still reach my goal without continuing in the same manner. So I guess I did look at it but discovered that, for me, those were not really options if I still wanted to do, you know, what I said [to be an engineer].

The women were determined to not let obstacles deter them from accomplishing personal success. This mindset served as the ultimate factor in their perseverance.

Therefore, when Christine dealt with challenges in her undergraduate engineering program, she relied on her internal determination and perseverance to proceed. She stated,

> You know I have been, I'd say successful in what I tried to do and it's because I don't have a spirit of giving up and so if I would have given up long ago I would have never finished school but I just never gave up. I mean I had to probably repeat a couple of classes, and I just didn't let that stop me.

At their core, the African American women relied on their individual spirit of determination to get them through the difficult times, at each level in their career. As Toni stated, "I knew I didn't have the quitting spirit;" therefore, the women were not going to give up before accomplishing their goals. Due to their determination and perseverance, quitting was not an option for them.

Macrosystem Perspectives of Support

Support within the macrosystem level included support from family and friends, teacher/counselor assistance, and factors in college and the workplace, which positively impacted the lives of the African American women engineers. The support system factors in the educational environment included teacher/counselor impact, pre-college program, university resources, and the minority network. The support factors in the workplace included mentors, managerial support, and the company structure. Aspects of each factor are presented in this section.

Family and Friends. The encouragement and grounding provided by family, friends, and significant others played a pivotal role in the lives of the participants from

early childhood experiences and throughout college, and continued into their professional experiences as well. Whether the familial support system exemplified tough love or unconditional support, the outpouring of encouragement provided the foundation the women needed for strength and resiliency. As a young child, Christine knew that her mother valued education and, therefore, supported her efforts as a young student. She stated,

> My mother was the main one who was always there, who made sure that we had what we needed. I remember someone mentioning, "Are you going to college when you get older?" This was when I was much younger, and it was kind of like a question mark. And I looked to my mom, I was like, "I don't know." She's like, "yes you're going to college!" She answered for me because I was young; I didn't really know, and you just kind of do what your parents tell you to do. And so I knew I would go to college eventually. And she helped us with our homework, she was very positive in just helping us along with what we needed. She was always there for extra-curricular activities.

Christine's mother planted the seed regarding the importance of education, which later grew into determination for accomplishing her educational goals. Similarly, Tiffany's parents shared parallel sentiments regarding the importance of education, from an early age, not only for her but for her two sisters as well. She noted,

> But they always were very strongly focused on education. One example was they sent my sisters and I to private school when we were very small. And, you know, my father would work overtime [and] my mom; they would work extra

> time so that we could go [to the private school]. . . I think it gave us a really great start in terms of like our. . .training, from a young age, and you know like learning is fun; it's cool to be smart and things like that.

Tiffany's parents made sacrifices to support their children's education, which nurtured their commitment to education and reiterated the importance of learning. This demonstrates the importance of the family unit in supporting educational goals.

In addition to the immediate family, friends and extended family members played a key role in supporting the participants. Josephine's extended family played a significant role in stressing the importance of education and leading the way for her. She shared,

> In fact most of my cousins are engineers. Electrical engineers, believe it or not. There's one mechanical. . .and most of them actually went to (the same college) too, by the way. So, as far back as I can remember, with my immediate family and my extended family, you know my mom, my aunts and uncles, always encouraged us to do well in school and to go to college. And the rationale was so that we could have a better life.

Likewise when immediate and extended family members were not available for support, the participants shared the role that significant others played in encouraging them and keeping them focused in college and in the workplace. Lisa shared,

> My parents and grandparents, my whole family was very supportive. Both sides of the family, very few people had gone to college and graduated; and then the fact that I was pursuing a technical field was something that was a big deal and

> so everyone was. . .rallying around me from an emotional support structure. And then my husband now but boyfriend at the time, he also was pursuing engineering. He obviously was a big supporter and [the] person to bounce emotional angst about class or whatever. . . He was someone that I could talk to about it without feeling like I was going to get in trouble or whatever.

The support from significant others and friends was crucial, particularly in college, when parents and other family members were not immediately available. Ultimately, the women relied on their family, friends, and significant others for the motivation to persevere when they wanted to consider other options, or just got tired of dealing with the workload, the difficult coursework in college, or challenging workplace environment. Family and friends provided the stimulus, which kept them going to become the engineers they were destined to become.

Teachers and Counselors. The women shared enjoyable K-12 experiences in the classroom with the teachers and received additional support from the counselors. In elementary school, the participants described their teachers as overwhelmingly good because they were nice and caring. On the other hand, Nicole noted that some of the teachers chastised her when she got into trouble. However, she knew it was due to their caring and supportive nature and because they wanted the best for her and other students. She shared,

> If you (were) in the hall cutting up they didn't care if you were in their class or not, they pulled you aside and reprimanded you. . . Or you know when you did well and you had a school assembly, they (may not have been) your teacher but

> you would hear them come by and say 'oh congratulations, I'm so proud of you, good job' or something like that.

Teacher care and concern increased the participant's confidence in their academic pursuits and provided an additional boost for their long term goals. Josephine had fond memories of her teachers and felt that they cared about the students and their learning because "you actually saw them in the community. And so I actually remember that. . . they all encouraged me." In addition to the teachers supporting the students, the counselors played a pivotal role in the lives of the students, especially in high school. Jasmine described her experience with the counselors during her high school career. She shared,

> The best part about it (was) the counselors. The counselors were truly in tune with their students. . .they pushed the African Americans a little bit harder because, at that time, you start seeing little programs come up and summer programs where you can go and further your education or just learn a little bit more. And how we (African Americans) would never come in and apply, so they would [say], "hey I know [you're] in such and such a class, why didn't you apply?" Well I didn't know anything about it. . .ok "well hey come to my office, I'll help you fill out the application;" stuff like that. And so the counselors were the best thing, and you could go in and you could talk to them about anything. They never made it seem like it was trivial, and they didn't show favoritism; it was just like everybody is important.

In the K-12 system, the teachers and counselors provided key support systems for the women in terms of reaching their academic goals and getting them involved in extracurricular activities which would help them in college.

Although most of the participants stated that at the college level, the professors did not show care and concern for their success as a student. There were a few participants who, although shared the same sentiment for the majority of the faculty members on their respective campuses, also recalled having one professor who was supportive during their college tenure. For example, Christine described a faculty member who was particularly supportive by stating:

> There was one in particular, a Black professor who just really helped me along and just encouraging; that was more in upper [division courses]. I may have been a junior and I'll never forget. . .and he went to like (a top tier engineering university) and he was this professor there and just so great and so smart. He was just a very, very, a good role model for me being his student; so it was good.

In most cases, the one professor identified by the participants was not in the engineering department. Nevertheless, having at least one faculty member who demonstrated care and concern helped the students to feel welcomed and supported in their undergraduate engineering programs.

For the most part, the participants shared stories where they felt supported, encouraged, and connected with teachers in the classroom and outside of the classroom in K-12 and, to a small degree, in college. These positive interactions helped the young

African American women sustain the often hostile and unwelcoming engineering environment in order for them to continue their journey on becoming an engineer.

Pre-College Programs. Several of the women participated in pre-college programs, either the summer before their senior year in high school and/or the summer before their first semester of college. Participating in these programs helped them acclimate to the campus before the larger study body arrived. Lisa shared,

> I participated in the pre-freshman program that they have. . .where you take the entry level freshman classes for math and English and maybe a couple of other classes so that you get college credit before the masses show up in September or August. And it allows you to get used to the campus, to make friends, and even though it's a huge campus, in the summers at that time, you know things were manageable as far as you not really knowing where you are and there is a sense of community in that program to where you. . . [develop] friendships or just support structures that you wouldn't have ordinarily, and so that was good and some of those people I continue to be close with throughout my time there.

As Lisa shared, the pre-college program initiated the formation of the women's supportive peer network on campus. Josephine's participation in a similar program helped her to create a community on campus. She stated:

> It was called the (pre-college program) for high school students, you know that summer before my senior year in high school. They also, went to (the university), so I went there already having a support group in place, between my cousins and some of my classmates for that high school program.

For some participants, the pre-college program was also an opportunity to see students of color specifically and develop community relationship with other minority students before the majority population returned to campus. Monica shared:

> So my first experience at (the university) was with all Black people, right. So (the pre-college program) was a program for the students that had received the (university) scholarship. . . And those were minority scholarships. So, for the most part, it was African Americans and Hispanic students. And so if you received that scholarship, then, you were able to go to this program. . . And (the pre-college program) was a summer program; you went the second summer session. You actually enrolled in two classes, but you lived on campus with all of the students that were in that program. . . So this is how I felt; I called my mom and said, 'mom, there are other smart kids, Black kids up here! And there are smart Black boys and they're cute!' . . . So when I got to (the university) and everybody was coming from pretty much the same background that I came from, it was just like the best thing ever!

Monica transitioned from being one of three 'smart' Black students in high school to joining an enclave of students with similar academic goals and skill sets. This network was especially important for the participants who attended predominantly White institutions as this was the space to bond with other Blacks, including women, in engineering. However, even for the participants who attended HBCU's, the pre-college program helped them to establish a peer support system and connect with other like

minded students who were focused on academic success. Nicole shared her experience at an HBCU:

> Before I went to (the university). . .they had this thing called (the pre college program). And that's where all those scholarships came; it was from that (program). . .they went and grabbed the brightest Black kids from all over. Valedictorians and salutatorians from Georgia, Chicago, New York; I mean it was like a whole conglomerate of Black folks. . . I had never even really knew they had that many smart Black people period, because you know of where I came from. . .it was always onesies and twosies. Then I get here, and all these people. . . I mean sharp as I don't know what. . . From day one, I met my very best friend. . .she did electrical engineering and she still serves in that capacity. . . she was in the honors college as well so there's a whole group of these honors kids, that are a subset of everybody else on the campus. . .and so then, I initially already had this little family, this little clique.

The pre-college programs provided a valuable network for these women to connect with other students who would support them, challenge them to be their best, and serve as treasured friends, in some instances. In addition to meeting other students, these programs provided a nice transition for the students to get adjusted to life on campus, away from parents, and to establish a routine or adjust to their new life as a college student.

University Resources. In terms of resources provided by the university, receiving financial aid was fundamental to supporting the women in college. Regardless

of the family structure, whether it was a two parent household or a single parent, the women relied on financial resources during their college tenure. As Nicole shared, "I really knew my home situation and I didn't want me going to college to be a financial setback for my mom." Consequently, Nicole selected her undergraduate institution based on the scholarship package received and estimated family contribution. Therefore, financial resources were a significant factor in determining the college of choice for the majority of the women. As Lisa shared:

> And when I got all the applications sent out and got the financial aid scholarship applications and all that sent out then it simply became a numbers game because . . .the fact that I was getting accepted into the schools and then that they were then offering scholarship money, then it simply became who is going to offer the best financial package.

Scholarships from the university in conjunction with funding from independent organizations provided the financial resources needed to cover the majority, if not all, of the expenses during their undergraduate programs. However, financial resources were not the only way the university supported the women in obtaining their degree. In addition to providing financial aid, university programming, offices, and efforts on campus assisted the students with accomplishing their academic goals. Christine noted resources on campus which provided assistance for her. She stated:

> I remember attending. . .when I first got there. . .it was like a conference. There were some sessions where you could go and they talked about minority issues and surviving. (Also there were) upper classmen helping the freshmen come in

> . . . I do remember there being an office as well where you could go and talk to someone if you needed to and so there were counselors there, a few of them.

Like Christine's university, which offered support services for all minority students, Tiffany's university offered programming specifically for students in engineering. She noted:

> But the one thing they (the university) had working for them, I think was great help for the students, was first they had a (support services) program, it was . . .for minorities in engineering. . .and they targeted bringing in minorities and supporting them through the engineering program. So it was all different areas within engineering but they provided workshops and tutorials. Like workshops in physics and math, because a lot of the students coming in didn't have those prerequisites, so they didn't have a strong background in those areas. . .so we had a person come in and actually provide all of our tutorials in the physics area and math. . .we started dominating (in those courses) and doing very well.

These types of programs and initiatives at the university and college level communicated to the students that the university cared about their progression in the engineering program. In addition to programming, having a dedicated office on campus in the engineering program further contributed to the academic and personal success of the young African American female college students. Lisa shared:

> It was just knowing that you could go in (the support office) and ask a question and someone would try to help you. The other part is I became a tutor for that group and so that allowed me to have some spending money and allowed me to

> meet other students outside of the (pre-college) program that I had participated in. It was a social avenue as well, you know it allowed me to meet, let's say the senior who was getting ready to finish in electrical engineering otherwise I would never meet that person. . . So it gave me an opportunity to meet people that I probably would not have otherwise made an effort to talk to.

Moreover, Jasmine described the director in the support office at her PWI by stating, "she was really, really good, and she really cared about the students, and she would know you by name." Jasmine was equally complimentary of the other staff administrator in the support office. She described her by stating:

> She treated you like one of her own children, you know, we had some moments, and we'd come talk to her and she'd sit down and. . .some days. . .she will even sit down and cry with you, because she said, "I understand what you're going through," and that's all you needed, because your parents weren't there.

The on-campus support provided by university administrators served as a surrogate familial support system in terms of motivation and encouragement. The university services, from financial resources to human resources, were instrumental in engaging the students and creating positive connections to the university. Ultimately, these connections and resources helped to retain the students in the program.

The Minority Network. The peer community, consisting of minority groups, served as the women's primary source of support on a daily basis. Their peer relationships provided assistance dealing with the academic and environmental challenges in their respective colleges and universities. The participants shared stories

regarding the importance of finding groups of people who shared common goals, namely to graduate from college. Consequently, an energy current developed with their peers, which thrust the group to keep making progress, despite challenges and barriers. Courtney stated:

> I would say. . .everybody's focus is to graduate; it's like you're there [at the university] to graduate. Even if you stay up all night partying, you know somebody's going to start cracking the books at 5 o'clock [in the morning]. So it's like we're all there for the same goal. And so I think you just pretty much (get) pushed by the entire environment.

The peer environment was substantial in supporting the academic goals and success of the participants. In describing the peer environment at her school, Tiffany shared, "I just got with a set of people who were succeeding. And I just wanted to succeed too." These enclaves were also beneficial for study sessions. Nicole noted:

> And then, of course, we had our little clique of students that were the honors students, we all studied together. We figured that out real fast, we figured out which students were good in which classes and those were the students that kind of led little mini study sessions. . . I mean we formed a tight little knit, that was our support group.

Much like the university administrators represented a familial support system, the peers and subsequent peer groups represented mini families as well. In most cases, the minority peer group consisted of other African American students in the engineering program. However, sometimes the minority network consisted of other women or other

racial/ethnic minorities. Josephine shared how her minority network was formed as a result of negative experiences with White students in her classes:

> So now you can imagine my first quarter there, and I'm like, I have to get a team and nobody wanted me to be on their team. With one exception, and it never failed; it happened every class, the students from other countries, who were of color. The first time one of them came to me, and said to me, they were being rejected just like I was, and came to me and said 'you know I'm being rejected by my classmates, no one wants me to be. . .a part of their team, and so I'm just assuming that the same thing is happening to you, is that true? I said 'yes' (and they said) 'so why don't we get together and have our own team' and so that's what happened. And guess what, these students were always the smartest in the class. I was like 'ok I got the hook up!' Yes ma'am. I tell you no lie, this is what happened, and so that's what got me through: my classmates from other countries that I teamed with on projects.

The minority peer network was based on forming strategic relationships with other students who shared the minority status. One of the primary drivers for the minority network particularly at predominantly White colleges was the National Society of Black Engineers (NSBE), an engineering student organization. The participants each shared stories affiliated with NSBE and how their initial network established as a result of being involved in NSBE. Monica stated:

> I was involved in NSBE, which was a really big help, a big support system. So even though it was only a few of us in the classes, you know we still felt like a

> tight knit community. Which I didn't necessarily have in high school, right. So that was actually a positive for me. And NSBE had a positive impact on me from exposure, going to conventions [and] conferences [and] from a professional standpoint, being exposed to the companies that would come to our meetings. I got my first internship through NSBE. So that had a positive impact on me. . .I was more drawn to NSBE because I needed that support group from other Black engineers. . .I pretty much studied with the people that were in NSBE.

NSBE was often noted for providing the opportunity for the African American college students to gather and support one another on the journey. In addition to NSBE, the other African American and/or minority student organizations on campus provided support as well. Tiffany described:

> They (the school) also had a very strong well organized NSBE chapter who planned before the students came in. I think the sororities and fraternities actually knew we were coming, they met us, I mean like the Black (fraternities) and sororities, they met us and helped us (and they) were available to answer our questions like 'where is this, where is that' and even if you needed some other kind of help that was really good. And then the Black student organizations got together and had a different event that first orientation week so we went to the movies and different little things I can remember and I made most of my close friends that very first week of school. So the community was very tight, the African American community was tight, and it made for a lot of success.

The minority peer network was a key component in supporting the African American female students and their efforts to succeed in the engineering program. Some universities provided programming and/or offices in the engineering department dedicated to minority affairs, and student organizations like NSBE to assist with transitioning to and graduating from the university. These networks proved to be invaluable for the participants.

Before entering the college environment, the women relied on family and friends and teachers and counselors as primary systems of support in their career development. In college, they participated in pre-college programs, utilized university resources and the minority network. Moving into the professional engineering workplace, the participants stated how mentors, managers, and the company structure supported their career experiences.

Mentors in the Workplace. As the women graduated from college and transitioned to the engineering workplace, they sought out a supportive network similar to their collegiate peers. To this end, mentors were valuable for the African American female engineers. Largely self selected, the mentors helped to guide their careers and supported the women as they sought to advance in their profession. Josephine shared how her mentor helped direct her to consider a different functional area of the high tech company to gain experience that would benefit her in her role as a researcher. The new position also provided exposure for future roles within the organization. She stated:

> So I wanted to learn more about (the company), plus I had a mentor who actually reached out to me, to mentor me, who began to share with me about the broader

> (company culture). And that I should really think about maybe. . .to take a two year assignment in development and understand how development works because it would help me as I go back into research and start thinking about projects, etc. So I took her advice and looked for a two year assignment in development.

Although, she took her mentor's advice, there were times when she didn't understand why her mentor pushed her in certain directions. Ultimately, however, she trusted her mentor; she also stated her mentor "knew the politics, she knew how things worked, so I made the decision to listen to her even though it didn't make sense to me. And so that was very helpful because that was very good advice." Therefore, mentors were able to provide guidance as the women navigated the engineering culture and their specific engineering organizations. Formal mentor programs worked for some of the participants, and for others, they sought mentors independently throughout the organization and with varied backgrounds. Jasmine worked in the oil and gas sector and recalled:

> You have a formal mentor that they set you up with, which was great, but I think every job I've been on, I've always been able to find at least one African American person, and I don't care if they're the professional degreed person, it really doesn't matter because what I found working in the refinery: the ones that were not degreed were your biggest cheerleaders. And they told you, "this is what it's going to take to move in this company, "oh yeah, I know that department, have you had a chance to meet such and such." So, I think for me

> I've always been one, "don't keep yourself closed minded, anybody can be your mentor, everybody has something to bring to the table.". . . And so I, I think that my circle has always been open and not just closed. . .it shouldn't just be African American; I need a wide variety. If you're going to be my mentor I need different perspectives.

Providing different perspectives was certainly valuable when a colleague turned mentor exposed Christine to the professional opportunities available to her as an engineering contractor. She shared,

> There was one guy that really took me under his wing; he was a contractor and… he was great at the software. . . So it was like he was a guru at this and so I would ask him all kinds of questions and he was very willing to help anyone who had any questions. So one night, we were working late and he was like, "you don't ask people what they make?" and I had no idea or whatever. He pulls out his check and (slamming it on desk), it was like. . . from one weeks pay on the desk. He was like, "this is what you do, I'm telling you what to do. You could be making that in a year if you just continue doing what you're doing and learning this; as much as you can about the system." And my jaw just dropped. I'm like, "what!" I had no idea. . .and my life changed after that. I was like, "you know what, I'm gonna do that. I'm gonna do that!" And so that's what I did, so I learned as much as I could.

Mentors served as vocal navigational systems to assist the women on their professional engineering journey in helping them reach their goals and reach their destination. In

some cases, the mentor provided detours to help them reach their destination faster and/or to expose them to different points of interest that added value on the journey. The mentoring role was so valuable to Josephine that she makes it a personal point to stress mentorship to young professionals, in addition to serving as a mentor. She stated:

> So, I tell, particularly young people now, mentorship, mentoring is extremely valuable. You've heard the adage time and time again, it's not what you know but who you know. Well actually you have to be competent, that's a given, that's the foundation but it's not enough to be competent. You really do have to have mentors who are in positions of power and influence, who can guide and direct and make things happen for you when you are competent.

The participants shared their stories regarding the importance of having a mentor who supported their career vision or provided vision and believed in their success as an African American female engineer. Although the mentors represented varied race/ethnicities and were male and female, the common goal that they shared was providing committed support to the women. Having mentors with influence were equally valuable as having managers who provided support for the women.

Managerial Support. Managerial support was just as significant as a mentor in the professional lives of the African American female engineers. The managers provided resources for their current projects and interests, assisted with personal issues, and supported their career development. Having a manager who did not support their efforts as an engineer could have been stressful; fortunately, Toni shared the counter

perspective. In addressing her support system in the utilities and power industry, she stated:

> I think definitely having a supportive boss. My boss is an engineer himself, so he understands what it's like to be an engineer, your career goals. We share that definitely through our annual, semi-annual reviews; he knows what I like to do. He makes sure that it's paid for, so that hasn't been a stress on me.

Likewise, Christine received accommodations from her manager when she wanted to work from home while working for an aerospace organizations. She had a challenging 45 minute commute, one way, from her home to her job site and desperately wanted to telecommute. Thankfully, her manager suggested that she try working remotely as a new schedule. She recalled:

> I remember getting sick and that's not something I usually do, probably my resistance was really low and trying to drive and I just couldn't do it one day. And I called my manager. . .I said, "you know, I'm not gonna be able to make it in today. I'm sick, I need to rest" and he's like, "you know what, you're doing such a great job, I really don't mind you doing this full-time." . . . He said I know. . .you've got the baby, I mean he was just great. . .and they're really happy with what I'm doing and I needed some more time at home.

Managerial support and flexibility in work scheduling kept the women engaged and connected to engineering while balancing commitments outside of the workplace. Similarly, Jasmine needed to change her work setting, to a different city and state. She was working in a remote oilfield location far from her hometown when she learned that

her mother was diagnosed with breast cancer. She was planning to quit her job and move back to her home city with her mother. However, her boss presented another option. She shared:

> I didn't even want to tell the manager. Somebody must have told him because he came to me and said, "I hear you have some issues at home," I said, "yeah." I said, "I think I'm just gonna have to quit because family is more important." He came back two days later and I had a transfer; they had moved me back to Texas. He said, "I can't get you home, because we don't have anything at home but this right here is the closest we can get you." And, you know, it makes you say, "ok, [there are some] bad seeds that you encounter but overall, it was a really good environment.

In addition to supporting the women from a work/life balance perspective, managerial support extended to recognizing the women as top talent within the organization and nurturing them as rising engineers. Due to Monica's relationship with her manager, she was nominated and selected to participate in an internal company program for high performers in the chemical manufacturing industry. She described the benefits of participating in this program and the long term advantage of being in the network, all as a result of her supervisor at the time. She stated:

> So I got training, I got access to mentors, and then I got to be on projects that I probably wouldn't have been on before and I really credit this boss. . . I mean I told her I'm interested in mergers and acquisitions. . .from an environmental standpoint. So she gave me a project for a very small acquisition where I was

> there main contact. And then once we made this very large acquisition of (another company), she put me on that team, and that opened up a lot of opportunity that I probably wouldn't have had before.

Managers can play a pivotal role in career progression by creating opportunities for visibility and development. Nicole shared similar experiences with her managers, who helped her accomplish professional goals in her career within the same engineering organization. Their support helped her promotion at the research company. She stated:

> Usually it has been my managers that. . .know the quality of work, the caliber of work, my work integrity and my ethics. It's been usually my managers who have fought for me to get to where I am now. So, I've had one African American male manager and he definitely took me to the next level because it was in his group that I got promoted to senior member of the technical staff. Just recently when I first moved over to this quality area. . .the project that I was supporting happened to go to the new manager, who happens to be White. A White male but it's a White male that I worked with when he was staff and I was staff. . . So he knows what I bring to the table; so him as a manager for me, he's very supportive. So I don't really want to leave out of his group because I know he will probably be the one to push me to the principal member.

Nicole relied on support from her manager to help her accomplish her career goals within the organization. In most cases, the managers described by the participants were the ideal managers for supporting career growth and development. They provided opportunities for the women and assisted with expanding their professional skills.

Although every manager did not fall into this category, the majority of the participant's experiences included having helpful managers in their support system at the workplace.

Company Structure. The women identified their company's structure as supportive of their career goals and interests within and outside of their primary functional area. The organizational structure was considered supportive largely due to the flexibility of the company to support their values and interests as a person and an employee. Being self initiated regarding her career goals, Jasmine appreciated her company's fluid perspective toward career development and career management. She shared:

> But as you move through the company. . .the opportunities are outstanding. . . In twelve years my career has boomed. . . I came in as the field engineer, working on the rigs, on the platforms. Through my career I've moved through line management. . .production. . .human resources. . .training and development. . . Now, my new role is, I'm the environmental analyst, so I deal with green chemistry and new product development and setting the company's direction for the next two years. . . So the first three years is fixed step. . . And after three years when you really start thinking about your career because you guide it yourself. . . I will tell you what keeps me going also is that I get a chance to take a break from engineering as well. I get an opportunity to come out and go back in every two years, so it gives me a chance to see something else, I don't get bored.

Jasmine joined a company culture which resembled her personal approach to career development regarding movement, fluidity, and frequent challenges and opportunities.

It was important for the women to work in an organization that matched their desires as a professional. Monica shared a similar perspective regarding her company and the ability to obtain different roles within the organization. She stated:

> I think it's just the roles that I've had, have been interesting to me. The thing that I like about (the company) is that with an engineering background, you can kind of do several different roles. . . I am thinking about, for my next job, doing something different, maybe like purchasing, maybe like supply chain. So I am thinking about doing something different but that's really because I'm thinking long term; what's going to be best for me in terms of my career path because I don't want to do traditional manufacturing. . . So, when I look at what's going to allow me to progress, do I want to stay doing EH&S (environmental health and safety) because I've done that for so long that at some point, I'm going to hit a ceiling. So this is a good level for me to go do something different and to learn a totally different skill set and. . . I think I'll be able to progress higher that way.

Likewise, Josephine stated that her company was able to create a job that matched her personal interests due to relationships she formed with colleagues in the organization. She described,

> So what I do now, my job. . .is focused on (Africa). Even outside of (the company) I'm volunteering for this non profit to help build a technology park in (Africa). . . And I've been doing this probably for about 4.5 years and it is amazing what has happened from a technology perspective on that continent in 4.5 years. . . You know what I was doing as a volunteer, very passionate about it,

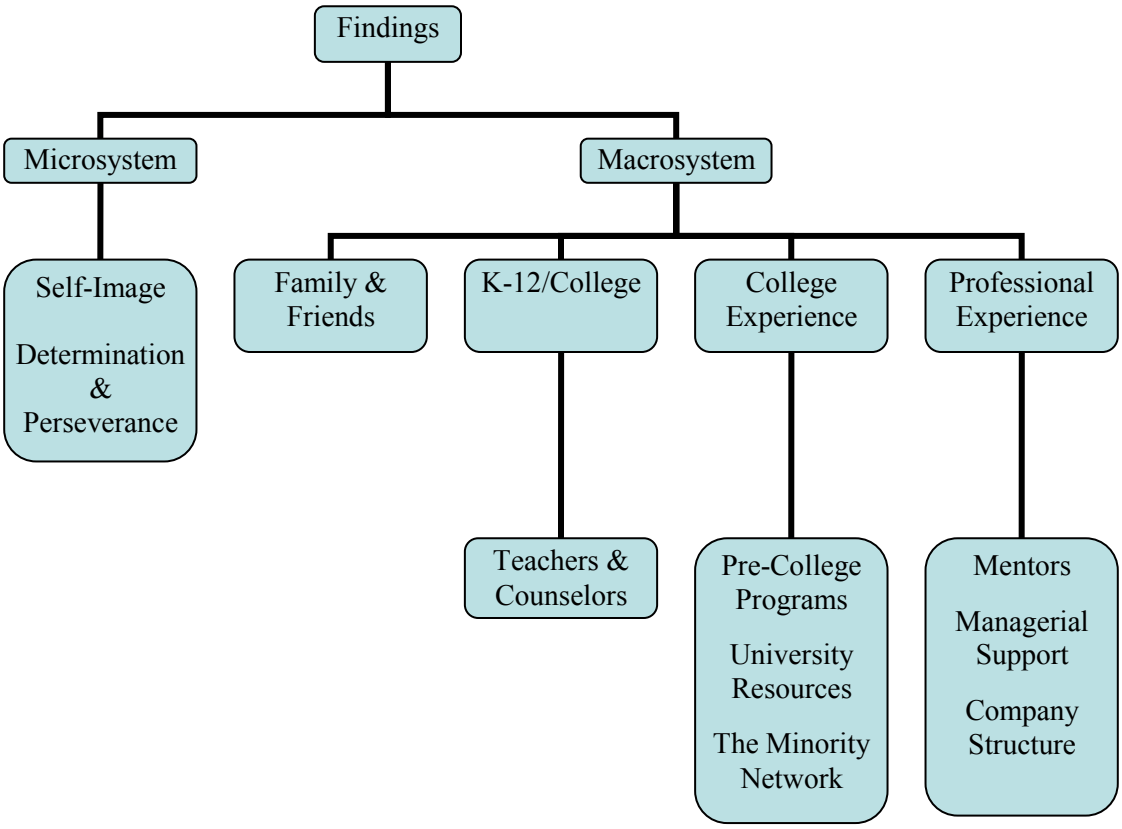
> [and I] told quite a few of my mentors who over the years have moved up in the company. So they're in very high level positions now. . . [I] asked for their support and most of them have been very supportive. Because they knew of the work that I had done in. . .Africa and my passion for it, one of them approached me with a job. . . So that's how I got the job that I have now. It's interesting how my night job has more or less become my day job and vice versa.

The company structure, combined with a strong network of mentors and managers, supported Josephine and all of the women and their self initiated career progressions. Moreover, these factors served as significant retention tools for these organizations. Ultimately, these systems of support contributed to retaining these top African American females in the engineering field.

Discussion

The purpose of the study was to examine the factors which served as support systems for the African American female engineers. The ecological framework provided the theoretical underpinnings used to examine the data, specifically the microsystem and macrosystem factors that contributed to the career experiences of the participants. The microsystem focuses on the individual. The microsystem factors which emerged from the data include self-image and determination and perseverance. Figure 4 provides a graphical representation of the two primary categories and subsequent findings. The macrosystem level factors include elements in the environment, which are external to the individual.

Figure 4
Graphical Representation of the Research Findings: Support System



Macrosystem factors which served as systems of support for the participants included family and friends, teacher/counselor support (in the K-12 and collegiate domain), college experiences, and professional experiences. The college experience revealed three key areas which served as support, including participating in a pre-college program, utilizing university resources, and aligning with the minority network. Similarly, three key components emerged as systems of support in the professional

workplace setting, including mentors, managerial support, and company structure. The discussion section begins with the microsystem factors.

Microsystem Perspectives of Support

The primary factors in the microsystem were having a strong math and science self-image combined with an internal spirit of determination and perseverance. The messages the participants received about their intelligence and natural abilities in mathematics and science gave them confidence and nurtured their self- image. The participants were secure in their capabilities in math and science from early childhood and their image continued to be affirmed throughout their education. Consequently, the foundation was established for them to forge ahead in the engineering pipeline. Gill, Mills, Franzway, and Sharp (2008) noted similar findings in their research on high achieving women in the workplace. They found,

> One common feature of the women's school experience was that they took pride in their achievements in the areas of maths and science; they believed they were good at these subjects in the sense of natural gifts. They emphasize this feature – 'very good', 'really good' – but there is no sense of boasting; it is just a feature that distinguishes them. (p. 227)

This data supports other research in this area, which notes the importance of having strong capabilities in math and science disciplines (Goodman et al., 2002; Levin & Wycokoff, 1991), which leads to greater confidence in the classroom and in the pursuit of an engineering degree. Other literature related to this topic often refers to women's self-efficacy and self-concept interchangeably, as it relates to the environment (Bonous-

Hammarth, 2000; Lam, Doverspike, Mawasha, 1997; Wender, 2004). Specifically, it is noted that the environment can affect the persons confidence and identity (Gill, Sharp, Mills, Franzway, 2008), which can support or hinder women pursuing careers in STEM.

Despite the challenges they experienced along the way, the women were determined to persevere; therefore, quitting was not an option. Of course, they could have stopped the journey at any point, however, in their mindset, there really were no other alternatives. Levin and Wycokoff (1991) studied factors which impacted persistence in engineering programs. There were two types of students discovered: those who persisted and graduated from undergraduate engineering programs, and those who decided to pursue a different course of action. They found, **"**These two types of students, successful non-persisters and successful persisters, illustrate that doing well in engineering is not merely a function of only academic ability or only interest. Instead both ability and interest must interact for successful persistence to result" (p. 466). For the participants, their determination to succeed certainly advanced their interest in the field. They were determined to persist and make their goal of becoming an engineer a reality.

Pre-College Macrosystem Perspectives of Support

The macrosystem included several factors which supported the women's career experiences, from childhood experiences to their current workplace organizations. Those factors included family and friends, teacher/counselor support, pre-college programs, university resources, the minority network, managerial support, and the company structure. Initially, the foundation for support was established by those closest

to the women, that is to say their family and friends. The family unit was significant in providing the groundwork for the importance of education in the household. Family and friends were critical for providing informal learning and support outside of school and for providing encouragement during the schooling years.

Each of the participants knew they were going to college from an early age and knew that the family unit would support their efforts every step of the way. Therefore, the participants shared information complementary to the research presented by Goodman et al. (2002), particularly regarding the important role played by the family. They found:

> Most students made the decision to major in engineering before they entered college. Mothers and fathers were highly influential in students' decisions about the major, with over 70% of respondents citing a parent as the most or second-most influential factor in their decision to pursue engineering. (p. 167)

Correspondingly, the Catalyst (1992) report stated the importance of exposing girls to engineering at an early age. Etzkowitz, Kemelgor, and Uzzi (2000) reported the influence of parents, especially fathers, in supporting education and careers in STEM. The participants noted that their fathers were instrumental in introducing them to informal engineering concepts. Likewise, both parents were clear about expectations for them to do well in secondary education and to continue making progress in college. The positive support, feedback, reinforcement, and support from family and friends contributed to the women's development in engineering.

Whereas family and friends supported the women outside of the classroom, teachers in the K-12 education system had a profound effect on the lives of the young female students. The participants noted how their teachers took an active interest in their lives inside and outside of the classroom. Additionally, the counselors showed a similar care and concern about the student's success. Goodman et al. (2002) found that teachers in secondary education are credited for encouraging women to pursue engineering. They noted:

> Teachers and guidance counselors can play an important role in guiding students to consider and prepare for an engineering career. Exposing girls in elementary school and middle school classrooms to engineering on a more widespread basis could help increase the numbers of women entering the major in college, and guidance counselors could also play a natural role in guiding or at least exposing female students to engineering and getting them to consider the field. (p. 176)

Likewise, Gill, Sharp, Mills, and Franzway (2008) and Gill, Mills, Franzway, and Sharp (2008) noted the important role that teachers play in encouraging women to pursue STEM fields. In the education system, particularly K-12, students explore their natural abilities, interests, and skills. The teachers and counselors guide the students on their journey and have the ability to nurture and support student learning. For the participants in the study, the teachers and counselors were key factors in developing their academic interests, particularly in STEM.

Macrosystem Support in College

After graduating from high school, the women's participation in a pre-college program was important in building a support system in college. In addition to establishing a support system, pre-college programs are specifically beneficial for students of color by contributing to their retention and success in STEM disciplines (Maton, Hrabowski, & Schmitt, 2000; Palmer, Davis, & Thompson, 2010). Pre-college programs, particularly the summer before the first year of college, assisted with the transition from high school to college, academically and socially. One program that has been particularly successful with retaining students of color in STEM and getting the students to not only graduate with undergraduate degrees, but also to pursue graduate STEM degrees, is the Meyerhoff Scholars Program at the University of Maryland. Three key components of the program include the summer bridge program, study groups, and program community. Maton, Hrabowski, and Schmitt described the program and some of its benefits:

- Summer Bridge Program. Once selected for the program, Meyerhoff students attend a mandatory pre-freshman Summer Bridge Program, and take courses in math, science, and African American studies. They also attend social and cultural events. The purposes of the Summer Bridge Program are to prepare students for the new expectations and requirements of college courses, and to provide social opportunities for interacting with peers, faculty, and staff.

- Study Groups. Group study is strongly encouraged by the program staff, as it is viewed as an important part of succeeding in SEM majors. Study groups promote academic support and create opportunities for social support and interaction.
- Program Community. The Meyerhoff program provides a family-like social and academic support system for students. Students live in the same residence hall during their first year, and are required to live on campus during subsequent years. In addition to peer connectedness, students are in continual contact with program staff, who are highly accessible and involved in student life. Program students and staff meet in large ``family'' meetings on a regular basis. (p. 633)

The Meyerhoff Scholars Programs and other related programs (e.g. Palmer, Davis, Thompson, 2010) are proving to be successful in retaining minority students in STEM. These programs include the elements that the participants stated were beneficial as women of color pursuing an undergraduate degree in engineering. Often, during the undergraduate experience, peer groups were the primary factor in their support systems. Therefore, these programs helped the women acclimate to life on campus and to form their system of support with upperclassmen and their peers. In addition to providing pre-college programs, universities needed to provide additional resources to support these women.

University resources, largely financial and human resources, at the college or university level provided substantial support to the women. Initially, securing money for

college was a key factor in determining which institution the participant attended. Financial burden, particularly for African American students, is often noted as a challenge for persisting in college. Thus, securing funding to attend college was vital and it allowed the student to focus on academic issues versus financial challenges (Lam, Doverspike, Mawasha, 1997; Maton, Hrabowski, & Schmitt, 2000). Moreover, support offices on-campus, specifically for minority students in engineering, provided additional opportunities to earn supplemental funds while in school by working as a tutor or student employee. However, the most important resources were the staff working in the on-campus support offices. They provided the familial connection, encouragement, and support resembling the family unit in the home. Some college programs offer dedicated counselors to work with students on academic matters and oftentimes include counseling on personal situations (Maton, Hrabowski, & Schmitt, 2000, p. 633). Staff members on campus provided the backbone for the students, as African American women in engineering. For the colleges and universities who provide these resources, it represents institutional support to the student and an interest in their success in the engineering program. Moreover, the university resources, in some cases, were instrumental in connecting the student with other minorities.

The minority network provided support for the participants during their college tenure by joining them with peers who shared common goals. The women noted that they became focused on accomplishing their goals at the university, and their peers shared common goals. While the participants were at predominantly White institutions (PWI), the minority peer group largely consisted of other African American students in

the engineering program. Yelamarthi and Mawasha (2010) stated, “Building communities for minority and female students in STEM is particularly valuable, as these students tend to feel relatively isolated in programs where they have traditionally been underrepresented” (p. 68). Feelings of isolation and exclusion were no different for the participants, as they shared stories where they represented the only person of color and/or woman in the engineering classroom. Therefore, the value of peer groups, particularly for students of color (e.g. Tate & Linn, 2005) is highlighted whether via mentoring (Budny, Paul, Bateman & Newborg, 2010), formal programs (e.g. Maton, Hrabowski, & Schmitt, 2000), or other peer networking opportunities (Goodman et al., 2002; Lam, Doverspike, & Mawasha, 1997). Peer networks are invaluable because, “In addition to offering social, emotional, and educational support, the clustering of incoming students into common sections serves as a buffer against "solo" or "token" effects” (Lam, Doverspike, & Mawasha, 1997, p. 63). Additionally, the peer network served as a basic support system, which also included studying together, challenging one another, supporting everyone, learning collaboratively, and most importantly connecting. Oftentimes, the minority student organization, the National Society of Black Engineers, served as the hub for the minority network. Brown, Morning, and Watkins (2005) stated that the majority of African American students are members of NSBE and/or participate in NSBE programming and events. Regardless of the group, whether formal or informal, the network was found to be a positive force in the supportive system.

Macrosystem Support in the Workplace

Similar to the established peer network on campus, mentors provided advice and guidance for the women and their career path in the engineering workplace. The Catalyst (1992) report examined success factors for women in engineering and reported:

> Nevertheless, nearly everyone agreed that coaching and advice from someone other than one's supervisor often make a critical difference in one's career advancement. This type of knowledge sharing often helps junior employees understand informal cultural rules and corporate politics, and provide a broader view of technical subjects. (p. 37)

In a follow-up report, Catalyst (2004), reiterated the importance of mentors in the workplace. Specifically, for this targeted group, the report noted:

> Three-quarters of African-American women report having a mentor as key to success. Among the women of color surveyed, African-American women are the most likely to have a mentor: 38 percent of African-American women surveyed have a mentor, compared with 33 percent of Latinas and 27 percent of Asian women. (p. 23)

As the literature indicated, having a mentor was a key component to the women transitioning from college to the workplace, as well as the continued development of their career. The participants' mentors served as coaches, counselors, and champions for the women. Whether formally or informally, male or female, or African American or another race/ethnicity, the mentors played a central role in the career experiences of the African American female engineers. Workplace organizations seeking to retain top

talent will need to provide and support mentorship for African American female engineers.

In addition to mentors, supportive managers in the workplace were also significant support systems for the women. For some participants, the manager acted as a counselor, and in other cases, the manager created opportunities for the woman to progress her personal career plan. The Catalyst (1992) report noted that some women engineers contributed their advancement in their careers and their success to the support received by their managers. Moreover, "Many African-American women report achieving positive relationships with managers and coworkers. They also report receiving support and coaching from other women of color in the workplace" (Catalyst, 2004, p. 23). From developing leadership and technical skills to issuing relocation packages for personal matters, the managers were top notch in putting their employees first. The participants' managers demonstrated care and concern for the African American women in the workplace. Furthermore, these are the management characteristics that will continue to support these women and other women of color in the engineering workplace.

The African American female engineers were self directed and ambitious. They had and have career goals that are varied within and beyond engineering. Therefore, they considered their company structure as a support system because it allowed them to explore options and opportunities in different functional areas within the company. Many companies offer rotational programs or structured development programs, which

are beneficial to employees and their future success within the organization (Catalyst, 1992; Gill, Mills, Franzway, Sharp, 2008). The Catalyst (1992) report noted:

> Rotational programs are also beneficial to women because they provide a variety of experiences and opportunities necessary for career advancement. Female engineers often lack certain types of work experience necessary for advancement, such as plant or manufacturing experience, because male supervisors feel that women do not want to be or should not be in certain work situations. Structured rotation programs that provide both women and men with a variety of work experiences, including research and production experience, help to remedy this situation. Female engineers spoke highly of rotation programs. They noted that such programs help women establish competence and increase their confidence as new line engineers. (p. 40)

Participating in structured development or rotational programs, or being allowed to informally craft a career plan allowed the participant's to learn about their company's culture, the organizational dynamics, and the many different opportunities available to them. The company structure supported their multiple interests and diverse backgrounds. The women enjoyed having options and exploring alternatives within the company structure. As a result of the organization's flexibility regarding career planning, the women remained engaged with the company and the engineering field overall.

Conclusion

The African American female engineers in this study had vital support systems which is the very reason why they are currently working in engineering roles for engineering organizations. It is important to note that these women were supported from early childhood, during elementary and secondary education, college, and even today in the workplace. For those truly interested in increasing minority representation in STEM, adding support systems throughout the pipeline will be vital to minority recruitment, retention, and success.

CHAPTER VI

CONCLUSION AND IMPLICATIONS

The purpose of this study was to examine the career experiences of African American female engineers. Specifically, one of the primary purposes was to understand what factors contributed to them entering and remaining in the profession. Therefore, the underlying focus of the study was to learn what factors served as support systems and challenges for the women as they navigated their paths to becoming and remaining engineers in the workplace. The life history approach allowed the participants to share their lives and the factors that contributed to their career development from early childhood experiences, throughout their academic career, and to their current roles in an engineering function. Using the ecological framework to ground the study, the data was analyzed and presented in two articles. The first article focused on the personal and structural challenges influencing the lives of the African American female engineers. The second article addressed the systems of support for the women. The articles presented the findings based on the category, either challenges or support systems for the career development of African American women engineers. This summary presents the findings relative to the system level: microsystem or macrosystem.

Summary of Findings

In the microsystem (individual level), the support systems included a positive and secure self-image combined with determination and perseverance. Their internal

beliefs were the grounding attributes for the women's support systems, which provided a strong foundation for the challenges they incurred. The challenges that emerged in the microsystem were discovered during the participant's college careers. The participants struggled with a lack of discipline and focus, difficulty learning how to seek assistance, and adjusting to the program rigor. These challenges typically occurred between their sophomore and junior year, as they transitioned from feeling comfortable with content covered in the basic courses to learning advanced engineering concepts. The women realized they had to work differently, and utilize support systems in their external environments. Ultimately, they persevered and graduated from their respective colleges and universities.

In the macrosystem (external environment), the family unit provided the underlying support system for the African American women and established the academic expectations for their path. Family support was complemented by teachers and counselors in the K-12 domain and minimally at the college level. For the African American women, interactions with these adults, during that particular time of their lives, provided confirmation and confidence that they were cognitively capable of succeeding in the engineering realm from an academic perspective. Some of the participants stated having one professor whom they felt believed in their academic capabilities and cared about their success as a student at the university. This of course, was not the norm. Nevertheless the single cases, where professors showed interest and care for the student, were significant and appreciated.

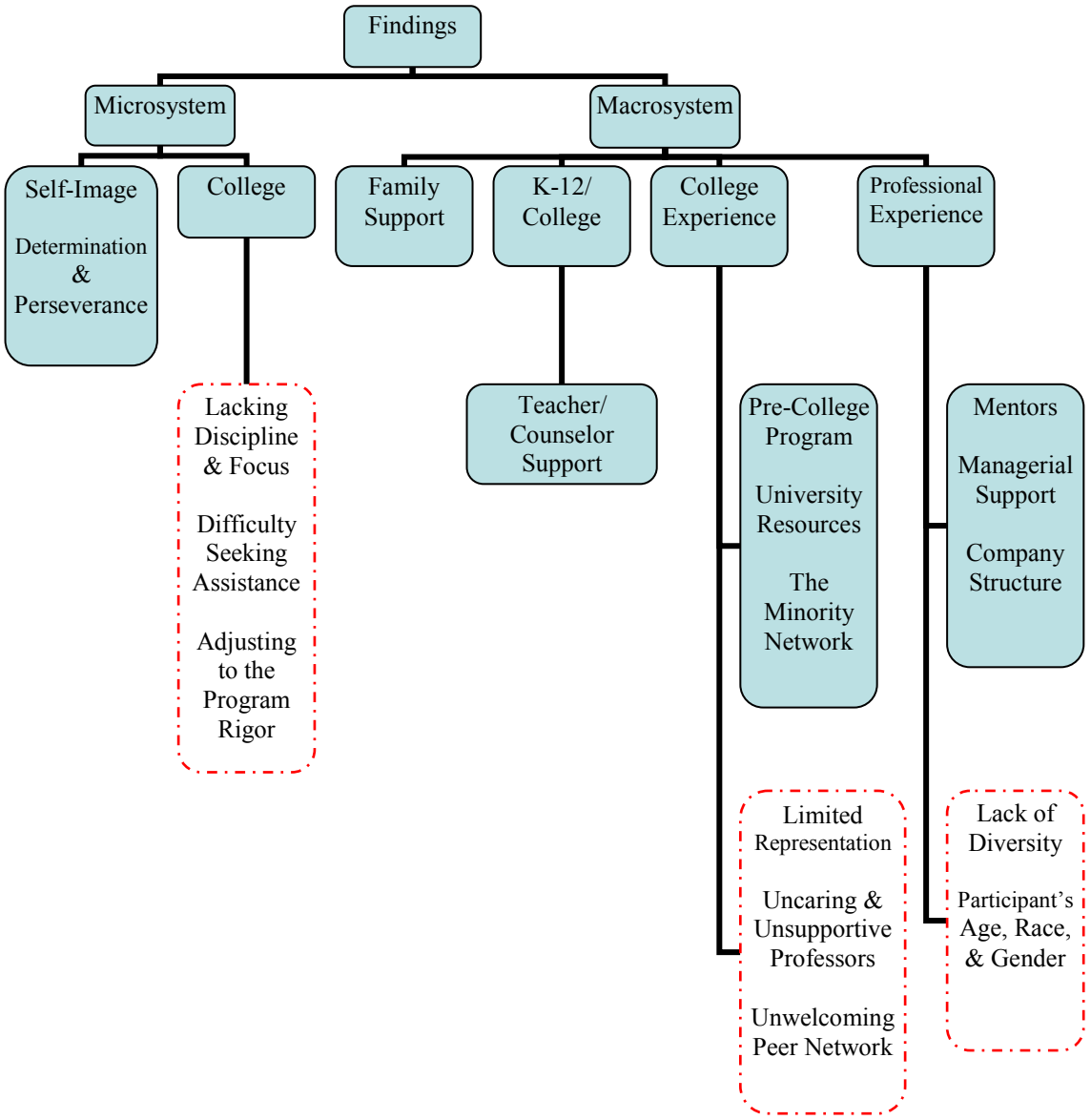
In the collegiate arena, the participants received vital support by attending pre-college programs, utilizing university resources (financial and human), and tapping into and connecting with the minority network. The systems of support provided comfort when dealing with the limited representation of women and students of color, uncaring and unsupportive professors, and feeling excluded from the majority peer environment.

At the professional workplace, the women survived and thrived, in some cases, due to caring mentors, supportive managers, and a fluid company structure, which supported their personal career progression goals. On the other hand, they had to deal with a lack of diversity in the workplace and negative experiences due to their age, race, or gender, or combination of those factors. Figure 5 presents a representation of the findings from the study. The dotted lines identify the challenges. The single line denotes the systems of support for the participants.

Thus far, the summary of findings has focused on what was found based on the data that emerged from the participants. However, it is also important to note what was not found in the data, based on the themes presented in the literature. One of the common themes addressed in the literature (e.g. Alfred, 2001; Bell, 1990; Turner, 1984) is the issue of biculturalism with women of color in predominantly White organizations. The participants in this study did not present this as an issue that they addressed as minority women in predominantly White male engineering organizations. They were aware of their racial/ethnic and gender identity; however, they did not share incidences where they felt they had to compartmentalize or assume different roles to function in the

organization. In several examples, it seemed that gender was just as dominant, if not more dominate, than race as a factor impacting their career experience.

Figure 5
Graphical Representation of the Research Findings



Another topic addressed in the body of literature, for women categorically and women of color specifically, was the influence of stereotypical images (e.g. Alfred, 2001; Collins, 2000, 2009; Johnson-Bailey & Tisdell, 1998). This issue addresses the notion that there are representations for how women work and capabilities of women, which can impact expectations from others about women and their patterns of work. Collins noted that negative stereotypical images were created and perpetuated to keep minority groups oppressed and controlled by the dominant group. She stated, "These controlling images are designed to make racism, sexism, poverty, and other forms of social injustice appear to be natural, normal, and inevitable parts of everyday life" (2009, p. 77). The images are created by the majority, those in power, to keep the majority in place (regarding social rank order), in an established position, and to justify the lower level and lower status occupied by minority groups. For the African American women in the study, they dealt with the stereotypical image that engineering is a White male field. As noted by Robinson and McIlwee (1991), "To be taken as an engineer is to look like an engineer, talk like an engineer, and act like an engineer. In most workplaces this means looking, talking, and acting male" (p. 406). Therefore, the challenges that were noted based on the participants' age, race, and gender each challenged the image that engineering is a White male field and to be an engineer is to assume an identity, mindset, and code of conduct that reflects the stereotype.

Although the participants themselves did not explicitly state stereotypical images as the challenge, their narratives provided the backdrop for this issue. One possible explanation for the women not explicitly stating stereotypical images is due to the fact

that they had not considered the stereotypical image as the underlying reason for their experiences. That is to say, as a person living the experience, they may not have the image clear for themselves or for the majority. Though it exists, it is not explicitly stated as the norm and therefore is not challenged as such. The underlying culture of engineering is to be valued as an engineer, which inherently excludes focusing on race and gender. Consequently, the approach to contribute and succeed in engineering is to focus on being a solid engineer, which places race, gender, age, and other social contracts in substandard positions.

The findings from this study add a critical missing piece in the STEM body of literature by providing empirical research on African American women in engineering. This study contributes information for a targeted group in the STEM discussion and provides implications for five distinct spaces: family, K-12, higher education, and workplace organizations.

Implications

Implications for the Family

One of the strong factors at the microsystem or personal level was the impact of family in supporting the women and their education journey. Fathers or male role models, in particular, played a pivotal role in introducing the women to engineering informally. Moreover, there were role models in the family and/or connected to the family who served as professional models for industry. This provided the foundation for the women to feel secure in their academic pursuits: focused on education on the surface and particular interests in math and science on a deeper level. For African American

families and communities, this notes the importance of family and community involvement in the lives of children from an early age. This involvement and support led to the women having a strong identity and confidence to pursue STEM programs in junior high and high school and continue in college. As minorities in the STEM fields, the women needed this positive reinforcement, as one of the few mechanisms that pushed them to continue and succeed in the field. The African American family and community need to rally behind the young generation in order to increase the numbers of African Americans overall and African American women in STEM. The family unit and communities have to take ownership of this action item as the beginning of the process to be represented in the STEM fields in the future.

Implications for K-12 Education

For the K-12 arena, the primary factor revealed in the data was a support system for the participants, which is an indication of the power and influence of teacher, counselor, and administrator support. Having educational professionals in the K-12 realm who believe in equitable learning for all students, and particularly supporting young women students and encouraging them to pursue math and science careers, will be key to educating the next generation of STEM leaders. It is evident there is an awareness of the influence of K-12 educators based on President Obama's (The White House, 2010) charge to gain 10,000 teachers in STEM by the year 2012. President Obama's initiative is certainly a required component for the US to make strides in STEM leadership globally; however, specifically for women of color, the K-12 educators (which include teachers, counselors, and administrators) will need to

aggressively support minority groups and believe in their capabilities and success. Additionally, for math and science educators, there has to be an equity orientation (McKenzie, Skrla, Scheurich, Rice, & Hawes, In Press) in the classroom and educational system for the success of students of color and women. Therefore, this study highlights that getting competent teachers combined with caring and equitable mindsets for the classroom will ensure a stronger basis for the female students of color interested in STEM fields in college and beyond. The implication for the K-12 education system is to support the young women of color in the classroom and in the educational environment overall, to continue to connect these students with summer programs, school programs, sponsored projects inside and outside of school, thereby creating and nurturing interest in STEM. This finding is important for this group, as African American women, in order to continue to develop their self-image in STEM.

Implications for Higher Education

In the college classroom there is a significant justification, based on the findings from this study, to make a critical overhaul to the engineering classroom environment, beginning with the faculty instruction and interests in student success for all students in the classroom. Traditional pedagogical methods, namely the lecture method, are limited in terms of engaging the current generation of students. This method of teaching not only disconnects with real world application of the material, but is also not student centered and does not consider the interests and needs of the learners in the classroom. Additionally, this method provides minimal opportunity to build rapport with the students, which is something that these women would have preferred from their faculty.

The participants wanted to know that the professors cared about their success in the classroom and in the engineering program overall. Adding innovating and inclusive teaching methods for engineering instruction is significant to retaining all students in engineering and to contributing positively to the learning environment.

On the other hand, the support systems provided by the university were critical to the participant's success. Colleges and universities will need to seek funding and dedicate those funds to programs that are directly linked to targeting students of color and women to pursue STEM (e.g. pre college programs/ high school camps) and to support the women and students of color once they arrive on campus in engineering programs. This item includes funding for offices dedicated to supporting underrepresented students academically, financially, socially, and personally. All of these factors should be addressed in order to support students of color and their success; in addition to increasing the numbers for women of color pursuing STEM in higher education.

Implications for Workplace Organizations

There are several organizations who have taken a step in the right direction regarding supporting African American women engineers in the workplace (Catalyst, 2004). These organizations support mentoring programs, provide managerial training, have women in key leadership positions, fully support rotational programs and self-initiated career progression, to name a few. However, even with these initiatives in place, the organization cannot rely on their effectiveness simply because they exist. Organizations should conduct internal assessments of the women and people of color

within their organization, listen to their feedback, and support the people in these roles and their career progression.

For organizations with hostile work environments, there has to be concern and action to address those areas within the organization. According to Bastalich, Franzway, Gill, Mills and Sharp (2007):

> The problem with engineering is that the workplace culture polices a narrow set of masculine norms and is intolerant of diversity. Within the engineering workplace culture 'women', or anyone who fails to conform to strict codes of masculine conduct, is cast as an 'outsider' or 'foreign'…There is a need to find a new kind of engineering image, one in which professional values, ethics and sensitivity to the effects of engineering outcomes in the world at large are emphasised. (p. 397)

For organizations with a limited and largely masculine mindset or culture, the leadership has to address this internally and ensure that women and people of color, the 'outsiders', are included in reshaping the cultural image where diversity is seen as a core value in the workplace.

Workplace organizations, overall, also have a vested interest in the engineering pipeline and will need to provide substantial funding and support to K-12 organizations and agencies, as well as to colleges and universities to get more women and people of color in the pipeline. Ultimately, it is the talent produced from these educational arms, which will assume leadership in professional organizations in the future. Moreover, the

diversity and ability for an organization to compete in the future lies on the talent produced by the educational system.

Conclusion

Overall, the implication is that we need to get more women and students of color in the pipeline and through the pipeline in STEM generally and engineering specifically. Increasing the numbers for minority groups also increases the support systems and constructively impacts student success for these groups as a minority in a majority discipline and majority organization. The numbers game alone indirectly addresses and positively impacts this groups' participation in engineering and STEM. This implication begins in early education, K-12, and continues to impact the college and workplace pipeline for women and people of color in STEM.

It's a national call to action to address the STEM population. As noted in the literature (e.g. National Academy of Sciences, 2007; NACME, 2008; Science and Engineering Indicators, 2006), we are a nation at risk, if we don't take a critical and holistic perspective for the STEM field, including early childhood, K-12, college, and the workplace. To examine one piece of the puzzle is to produce short-sighted results, or more aptly provide a band-aid for the symptom without addressing the root cause. This is not a K-12 issue alone or a higher education issue alone. This is an engineering community issue and we need all hands on deck to take charge and get the students we need, leading with African American females in STEM.

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APPENDIX A

SAMPLE INTERVIEW GUIDE

Interview Guide

Career Experiences of African American Female Engineers

I. Introduction and Background

Background information about researcher and purpose of the study
Background information about participant
Participant's current role
General descriptions about self, engineering, being an engineer, perception of engineering

II. Family Structure

Family culture and influence
Background and education
Immediate family including parents and siblings
Extended family including grandparents, uncles, and aunts
Family history in professional roles and education
Lessons learned pertaining to values and expectations
Significant events: positive/negative experiences
Family role (support or hindrance) in education and career
Expectations in areas like education, financial, and spiritual

III. Primary and Secondary Education

State of society
School environment/setting
Favorite subjects and strongest subjects
Extracurricular activities
Teacher(s) and other administrative staff (coach, principal, counselor, group advisor, etc.) influences
Pedagogical methods
Significant events: positive/negative experiences
Peer group make-up, experiences, and expectations
Academic and social accomplishments
Role models/mentors
Lessons learned

IV. Community

Community organizations, agencies and/or groups
Role of the church or spirituality
Influential people in the community
Role models/mentors

V. College/University Education and Experience

State of society

School environment/setting
Favorite subjects and strongest subjects
Extracurricular activities and student organizations
Teacher(s) and other administrative staff (counselor, group advisor, etc.) influences
Pedagogical methods
Significant events: positive/negative experiences
Peer group make-up, experiences, and expectations
Academic and social accomplishments
Role models/mentors
Major choice selection process for engineering and within engineering
Experiential education: Internship/co-op and other informal experiential learning experiences
Role models/mentors
Lessons learned

VI. Professional Experience

State of society
State of industry/organization
Factors influencing career choice and career journey
Role models/mentors
Colleagues/Peers make-up, experiences, and expectations
Support systems
Challenges and barriers
Professional engineering experience with different companies, different jobs
Significant events: positive and negative experiences
Job promotion(s) and mishaps
Impact of race and gender on career development
Current role and previous professional experience (within engineering and outside of engineering)
Career goals
Suggestions to parents, children, schools, college/universities, and workplace organizations regarding African American female engineers

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