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**Abstract**

The purpose of the study was to examine the career experiences of African American female engineers and explore their challenges and support systems during their career development. This qualitative study utilized a life history approach and was designed using basic interpretive inquiry. There were nine African American female participants in the study who currently worked in an engineering field within an engineering industry. Using an ecological model to ground the study, the findings were categorized as macrosystem (environment) or microsystem (individual) factors. The highlight of this manuscript includes a focus on implications, which offer insight into recruiting and retaining African American female engineers.

## Introduction

The critical need for underrepresented groups in STEM, specifically African American women, is noted in the literature (e.g., Engineering Workforce Commission, 2006, 2010; NSF/Division of Science Resources Statistics, 2010a, 2010b, 2010c; Rice & Alfred, 2014). At a National Action Council for Minorities in Engineering (NACME) roundtable, Nick Donofrio, Executive Vice President of Innovation and Technology for IBM, stressed the importance of diversity in the STEM fields 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.

The purpose of this study was to examine the career experiences of African American female engineers in order to better recruit and retain this group in the field. 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 (Cole & Knowles, 2001), 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 (Bronfenbrenner, 1977; Cook, Heppner, & O'Brien, 2002) to ground the study, the data were analyzed and the next section provides a summary of the findings relative to the system level: microsystem or

macrosystem. This overview is based on research that was reported as personal and structural elements of support for African American female engineers (Rice & Alfred, 2014) and personal and structural challenges influencing the career experiences of African American female engineers (Rice, In Press). After the summary of findings, the critical addition to this body of work includes the implications for each area of the STEM pipeline.

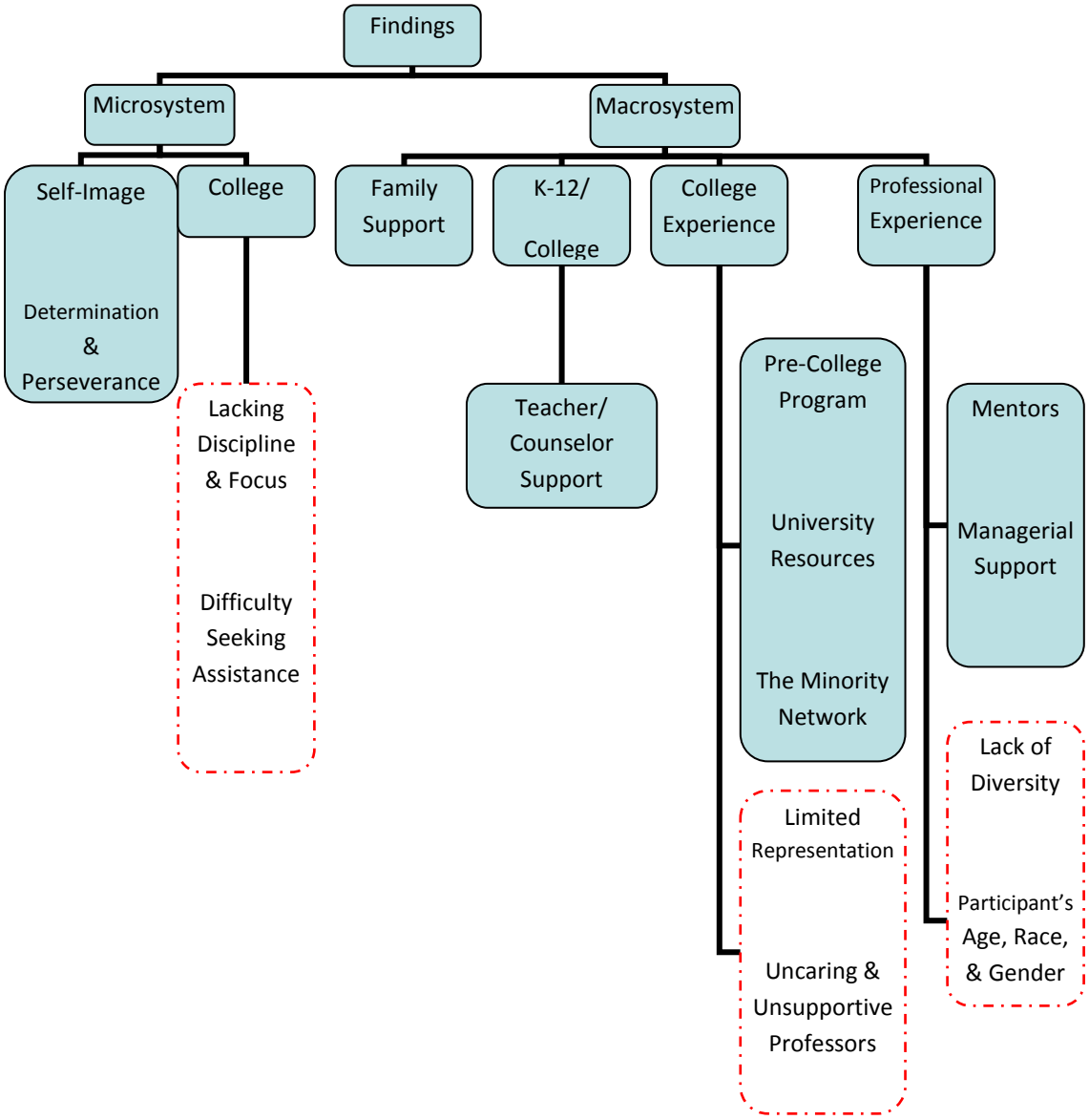
In the microsystem (individual level), the support systems included a positive and secure self-image combined with determination and perseverance. Their internal beliefs were the grounding attributes for the women's support systems, which provided a strong foundation for the challenges they incurred. 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 utilized 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 1 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.

**Figure 1**
*Graphical Representation of the Research Findings*




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.

Another topic addressed in the body of literature, for 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 their capabilities, 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 four 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. In order to education the next generation of STEM leaders, educational professionals in the K-12 environment should support equitable learning for all students, particularly young women and encourage them to pursue math and science careers. 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. President Obama's initiative is certainly a required component for the US to make strides in STEM leadership globally; however, for women of color, the K-12 educators (i.e. teachers, counselors, and administrators) 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, 2011) 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 disconnects from real world application of the material, is 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 the participants 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 innovative and inclusive teaching methods for engineering instruction is significant to retaining all students in engineering and to contribute 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 that 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 emphasized. (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, 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 of an organization to compete in the future relies 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. Simply 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 workplace 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 regarding the STEM field and include early childhood, K-12, college, and the workplace. To examine one piece of the puzzle is to produce shortsighted 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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