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Exploring the Experiences of African American Female Students in Engineering: A Narrative Literature Review

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Introduction

The dearth of African American students in engineering is often cited as a crucial area for improvement (Fletcher et al., 2016). According to the National Center for Education Statistics (2022), African Americans only received 5.0% of engineering degrees awarded in 2022. The declining number of engineering graduates among African American students causes alarm. Upon closer examination, in U.S. colleges African American women enroll at higher rates than African American men, comprising 60%–70% of African American student enrollment (Johnson et al., 2023). Additionally, African American women consistently achieve higher graduation rates across all academic levels compared to their male counterparts. Despite the progress African American females have made in postsecondary education, they continue to be underrepresented in engineering fields. In 2023, less than 1% of all engineering bachelor's degrees in the United States were awarded to African American women (National Center for Education Statistics., 2022). Understanding why African American women are underrepresented in engineering requires a systems perspective (Fletcher et al., 2016) because it involves examining the complex interplay of multiple factors across various levels of influence. This approach considers not only individual factors such as personal aspirations and educational experiences but also broader systemic issues such as societal stereotypes, institutional biases in education and workplace environments, and systemic barriers to career advancement. A systems perspective enables a comprehensive analysis that identifies how these interconnected factors interact and perpetuate disparities, offering insights into targeted interventions and policy changes necessary to promote equity and inclusion in the field of engineering.

There are three prominent reasons why the attention placed on the status of women of color in STEM is critical: (1) There is immense demand for STEM professionals in the current workforce; (2) Having the benefit of diverse perspectives and ideas can promote innovation and discovery; and (3) It is imperative to ensure equity and STEM access and literacy among all minority groups which in turn can advance our society technologically (Ireland et al.,2018).

Failure to advance the support and education of women of color and move them into productive STEM careers represents a failure of the United States to maximize our own talent pool at a moment when we can ill afford it—socially, technologically, or economically (Ong, Wright, Espinosa, & Orfield, 2011). Therefore, examining the literature that addresses the persistence of this underrepresented group can be an effective method to better understand, recruit, and support this population (LaMotte, 2016).

Most studies in the literature use multiple minority groups when investigating factors influencing students' persistence patterns in STEM fields (Brown, Morning, & Watkins, 2005). For example, African American students are

normally compared to White students or women in comparison to men, but few researchers seek to differentiate the unique challenges encountered by African American women. This accumulated approach prompts generic conclusions and suggest that all minority groups' educational experiences are equivalent in all STEM disciplines. When the unique experiences of Black women are hidden in aggregate results, their intersectional experiences are largely ignored (Ireland, Freeman, Proctor, Delaine, Lowe, & Woodson, 2018). Moreover, education research and practice efforts to address diversity issues in STEM have failed to adequately contend with the ways in which U.S. institutions have historically marginalized students of color while educationally privileging both Whiteness and maleness (Collins & Bilge, 2016; Ladson-Billings & Tate, 1995).

Given this current state, the purpose of this narrative literature review is to examine how researchers have explored experiences and discovered tools for persistence amongst this underrepresented population. Therefore, I sought to answer the following questions:

- How have researchers addressed the experiences of African American female students' persistence in engineering majors?
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- How have researchers identified and explored tools for persistence and degree completion amongst African American female students in engineering?

The context of Crenshaw, Gotanda, Peller, and Thomas' (1991) discussion of intersectionality was to confront the inadequacy of one-dimensional antiracist and anti-discriminatory discourse in addressing the sociopolitical concerns of Black women. In the past, scholars from several disciplines have struggled with how to interpret and conceptualize the term *intersectionality.* Crenshaw (2016) rightly clarified that her original articulation of intersectionality was a theory not of multiple identities but of how holding certain identities makes one vulnerable to discrimination and exclusion; in addition, she maintained that it is impossible to understand the challenges of women of color without examining the intersection of race and gender identities. Johnson-Bailey (2001) affirmed, "From primary school through higher education, their lives are touched whether overtly or covertly by racism and sexism and African American females in engineering face the double bind of being female and Black.

In the context of national efforts to promote diversity and inclusion within STEM fields, the *double bind* is cited as a hindrance for Black women throughout the educational and professional pipeline (Charleston, Adserias, Lang, & Jackson, 2014; Hanson, 2008; Malcolm, Hall, & Brown, 1976; Ong et al., 2011). The *double bind* refers to the exclusion of women of color in STEM and the undermining of their career pursuits because of both racism and sexism (Malcom & Malcom, 2015).

The concept of intersectionality, rooted in Black feminist theory, has particular utility for advancing discourse on Black women and girls beyond the initial framing of the *double bind*, which is why examining their complex and multidimensional experiences within STEM education is imperative for further exploration (Ireland et al., 2018).

Methods

I utilized a narrative literature review to describe the current state of practice and areas of inquiry. A narrative literature review is a comprehensive study and interpretation of work that has been published on a particular topic; it should convey knowledge, ideas, and their strengths, and limitations (Austin, A. E. 2011). This type of review can also add dimensions of insight/application that were not available in existing literature, can provide critical analyses of standing works, explore advanced new theories and models, evaluate strategies presented to improve best practices in the field and present new perspectives as they pertain to emerging issues (Rice, & Alfred, 2014). This study utilized scaffolding to develop better insight into the support and success of African American female students in engineering majors (Gregory,
2015).

Data Collection

To fully engage with the breadth of research addressing the experiences of African American women in engineering education and focus attention on the knowledge generated from this body of work, I removed the restriction on publication date and narrowed the inclusion criteria to include only publications reporting on empirical research or original analyses of African American women in engineering education (Ireland, 2018). I used the following criteria to select studies for review:

- Research content that focused specifically on experiences in engineering majors.
- Inclusion of STEM research only if it specifically identified African American female population experiences.
- Inclusion of studies of women of color, *specifically* African American female undergraduate students as the participants.
- Empirical research results and/or original analysis.
- Research studies that included book chapters, articles, and dissertations.
- Studies that explored African American female engineers.

To collect and examine dissertations, articles, and journals, I conducted electronic searches of the following databases: Elton B. Stephens Co. (EBSCO), Education Resource Information Center (ERIC), ProQuest Dissertations & Theses

A&I, Project Muse, and Education Full Text. I also used five peer-reviewed journals to explore current research in the field: *Journal of Engineering Education, American Education Research Association, Journal of STEM Education, Journal of STEM Education-Innovations and Research, and Journal of Diversity in Higher Education*.

The first phase of the research included seeking terms such as *minorities and STEM,* which yielded 14,354 results. These resulting studies focused on STEM majors as a group and did not take into consideration the specificity of majors within STEM (LaMotte, 2016). There are distinct differences between engineering versus science, technology, and mathematics. Engineering involves the practical application of science and mathematics, as in the design of structures and systems (Slaughter, Tao, & Pearson, 2015). Science, on the other hand, entails the systematic knowledge of the physical or material world gained through observation and experimentation (Steinmetz & Braham, 1993). The distinctions of the disciplines must be examined separately as each may possess idiosyncrasies that impact the persistence among various student groups in disparate ways (Gregory, 2015). Therefore, I narrowed down the terms to *"Minorities and women of color in engineering"* which produced 179 studies, a scope too large for the research. Ireland (2018) noted not all women or all underrepresented minorities are alike and Joseph (2012) noted that it is important to identify differences between women and ethnicity since "gender impacts how race and ethnicity are experienced; and race and ethnicity impact how gender is experienced" (pg 12).

Finally, I used specific key terms of *"African American, Black females in STEM"* which populated n=75 results. From the list of 75 studies, I eliminated studies by reading all abstracts and discarding those studies that did not capture specifically the experiences of African American women in engineering. After a thorough review, I used the search terms "*African American female, Black women experiences in engineering"* and found n=12 studies that met the minimum criteria for inclusion.

This extensive search strategy aimed to capture a broad spectrum of knowledge while maintaining a specific focus on the unique challenges and experiences of African American women in engineering. However, the study is not without limitations. Potential constraints include language barriers, access limitations to certain databases, and inherent biases in published research. Furthermore, the study's delimitations, such as excluding non-empirical studies and articles not specifically centered on African American women in engineering, help maintain a clear and focused inquiry but may omit valuable insights from other perspectives. Overall, while Ireland's research appears conclusive within its defined parameters, acknowledging these limitations provides a nuanced understanding of the study's findings and suggests avenues for future research to broaden the scope and deepen insights into this critical area of inquiry.

Data Analysis

To demonstrate how researchers have produced new knowledge concerning the education of Black women and engineering, I presented themes that emerged during the review of the literature (Ireland et al., 2018). This method helped identify implicit and explicit ideas within the findings of each study and was useful in capturing the intricacies of meaning within the data set (Casey, 2012). I divided the themes into two categories: *interpersonal themes* and *intrapersonal themes*. Interpersonal themes emerged from experiences African American female engineering students encountered when they had direct communication/interaction with fellow peers/engineering students, university faculty, and staff.

These themes included stereotype threat/microaggressions, racism, sexism, lack of support (faculty, institution, peers, and community), and lack of role models. Intrapersonal themes emerge when one's thinking takes precedence on self-perception and self-analysis while navigating uncomfortable/difficult spaces in engineering. The intrapersonal themes included isolation, self-doubt/need to prove oneself, and a sense of belonging. The themes also included tools for persistence that increased successful matriculation.

Table 1. Interpersonal and Intrapersonal Themes

	%	n
Interpersonal themes		
Racism/Sexism	25	3
Stereotypes/Microaggressions	33	4
Lack of support (faculty, institution, peers, community)	41	5
Lack of role models	50	6
Interpersonal themes		
Isolation	66	8
Need to prove oneself/self-doubt	41	5
Sense of belonging	25	3
Tools for Persistence		
Family/Friends	75	9
Faith	58	7
Student Organizations/ Campus Community	66	8
Desire to give back	50	6
Strong sense of self	41	5

Note. Twelve total articles

FINDINGS-Interpersonal Themes

Stereotype threat/Microaggression

Stereotype threat was present in a number of studies. Gregory's (2015) study was grounded on an assumption that African American women in engineering experience stereotype threat. Proof that stereotype threat existed arose during conversations concerning participants' description of an "ideal" engineering classroom, their need to prove themselves, and their overwhelming fear of asking questions in class. Similarly, Alter et al. (2010) found that stereotype threat impairs performance by stimulating avoidance behaviors such as non-participation. The results of this study suggested that the experience of stereotype threat also elicited decisions by African American female college students to stay or leave STEM fields (Alter et al 2010).

Beasley & Fischer's (2012) measure of stereotype threat, which is termed group-based performance anxiety, taps the extent to which students attribute their own performance as reflective of the academic competence of their race and/or gender group. Black STEM majors had the highest group-based performance anxiety, followed by Hispanics and Asians; Whites had the lowest scores on this measure (Beasley& Fischer, 2012). Massey & Fischer (2005) demonstrated that performance anxiety does hamper the academic performance of racial minorities. Gregory (2016) found that participants candidly discussed assumptions about their academic incompetence, expectations for them to lose their identity and conform, and negative perceptions about African Americans in general. These pressures specifically affected their ability to perform well.

Only two studies addressed microaggressions as a theme in the research. Microaggressions are behaviors and words unconsciously expressed and not intended to be offensive, however, they can have the same effects as conscious, intended discrimination (Gregory, 2015). Gregory (2015) defined microaggressions as a term used to describe "unintended discrimination" (pg 81). Six out of ten participants shared experiences in which they were victims of microaggressions.

Racism/Sexism

For some women of color, their gender, race, and ethnicity were seen as major barriers to being perceived as serious students by their professors (Carlone & Johnson, 2007; Brown, 2000). Frillman's (2011) definition of African American and female in engineering was relative to the participants' views of their day-by-day experiences within an overwhelmingly White and male discipline and in light of the identities of being female and African American. Participants' remarks indicated that sexism and racism were ever-present realities, but of the two

oppressions, sexism was the more severe (Frillman, 2011); this took the form of sexist behavior on the part of their male counterparts and instructors. They also spoke of feeling the need to earn respect and be accepted for who they were – that is, as African American and female. According to Rincon & Yates (2018), all African American women in their study referenced gendered racism, a hybrid phenomenon in which the effects of racism and sexism are experienced simultaneously. Although theorizing on why this may have been the case falls outside the scope of this study, others have explored how gendered racism has particularly significant effects on African American women (Rincon & Yates, 2018). A number of other women in Rincon & Yates (2018) study referenced an uncomfortable environment primarily due to gender rather than race.

Frillman (2011) also found that unique experiences from participants as African American women. The second most frequently assigned experiences/codes were sexist behavior from males, sexism more salient than racism, strategies for dealing with sexism, positive feedback from engineering team members, and having to earn respect as a Black female in engineering. Ong et al.'s (2011) synthesis revealed a number of studies on cultural bias against women and/or minorities that played a significant role in undermining the success of women of color. Brown (1995) found that faculty systematically gave lower assessments of minority women relative to those of their White and male counterparts; this finding held even when undergraduate GPA and degree field majors were considered. Of the negative stressors, Frillman (2011) found the most frequently mentioned were the salience of sexism over racism and the need to be one's own source of strength at times. There were other negative stimuli – e.g., poor teaching, difficulties caused by failures within the educational bureaucracy, financial pressures, and discouragement – but the women's responses overwhelmingly indicated that sexism was an omnipresent reality of their daily lives, along with the need to be one's own support system by default when necessary; these were their most frequent sources of negative stress (Frillman, 2011).

Despite marginalization, women of color often use their status as a member of two underrepresented groups—as a woman and as a person of color—to empower themselves (Carlone & Johnson, 2007; Ellington, 2006) this ties directly to the ways in which students understand and handle racism and to their subsequent ability to navigate the engineering environment (Samuelson & Litzler, 2016). For example, Hanson (2004) pointed to the construction of gender in the African American community as being congruent— and not at odds—with the personal characteristics needed for success in science: high self-esteem, independence, assertiveness, and high educational and occupational goals.

Lack of Support

LaMotte (2016) found that African American women did not receive the help and assistance needed from faculty; this support or lack thereof originated from faculty, peers, college administrators, and their home communities. Gregory's (2015) participants believed that both students and professors lacked an awareness of the obstacles they faced as African American women in a White male-dominated field. Many of them also shared that even though their families did their best to support and encourage them, they truly did not understand the academic pressures and social challenges African American women face daily in engineering (Gregory, 2015). LaMotte (2016) found that most of the women interviewed understood the importance of faculty and worked towards building positive relationships. In all instances, faculty-to-student interaction was an important ingredient to student success. According to Gregory (2015) many African American women who were in their junior and senior years developed strategies to develop positive and productive faculty relationships. The author discovered some of them expressed the work needed to build confidence, and to avoid or to work around faculty who were unapproachable. As a result, the women developed methods to build relationships within their cohort.

Lack of Role Models/Faculty Support

Ong et al.'s (2011) research study suggested that women of color seek out academic and personal support vigorously and with serious intent. These relationships serve to bolster their confidence and learning in STEM majors as well as their determination to graduate (Ong et al., 2011). Unfortunately, the void consistently was unfulfilled, and African American women in engineering tapped into a host of networks that included parents, faculty members from other departments, university administrators, and peers in and outside STEM fields.

According to Trenor et al.'s (2008) results, seven of their nine African American/Black women participants indicated that parents and family were supportive of their goals in a general sense, but did not specifically cite family as role models in the field of engineering. Rincon & Yates (2018**)** suggested that one potential hindrance to diversifying the engineering profession is the lack of confidence and encouragement from individuals who have a great influence on young girls' lives, including parents and mentors. Although most women in Rincon & Yates' (2018) study provided examples of support received from family, friends, peers, and teachers, many noted having few role models to follow on their engineering journeys. According to Rincon & Yates (2018), external support was critical to ensuring that there was someone with whom experiences could be shared,

with whom to explain what it is really like to be an engineer and to encourage their interest and success in the profession.

Gregory (2015) found that many participants experienced uncaring and discouraging professors. Participants discussed how their professors at their PWI were much less approachable than their professors at the HBCU they previously attended. Many participants thought that professors played an integral role in helping African American female students resist or combat stereotype threat and that they also had an equally powerful influence in igniting it (Gregory, 2015).

Participants in Sean's (2016) study identified at least one faculty member with whom they seemed to have a strong relationship. The professors with whom participants perceived the strongest relationships, however, were not always engineering faculty. Inspirational faculty relationships were equally prevalent across liberal arts, business, mathematics, and science faculty. African American women in particular were more likely to mention the positive impact that mentoring relationships had on their careers (Sean, 2016).

Shain's (2002) study indicated that, while their cultural identity was important to their educational experience overall, the cultural background of their key support person in the major was not a factor. Thus, women of color may make personal adjustments to suit the culture of their chosen discipline, such as seeking mentors outside their gender and/or racial/ethnic group (Ellington, 2006; Justin-Johnson, 2004). According to Rincon & Yates (2018), the gender or race of the mentor was not a factor when the relationship was a positive one.

FINDINGS-Intrapersonal Themes

Isolation

Alienation and isolation were major themes in Gregory's (2015) research. All ten participants asserted that they were typically the only African American female in their engineering classes, and sometimes the only African American. One participant proclaimed, "Everyone else has their own cohort. Until there is a project in which I am randomly selected on a team and you have to deal with me, no one is friendly. No one speaks or says anything to me. That makes me feel uncomfortable when I need to ask for help" (pg 54). These feelings of being alienated and isolated align with Brown (2004) who noted that African American women are often the most socially isolated group of students on campus. Other researchers have stated that this alienation/isolation fosters feelings of incompetence and cultivates fear of failure (Ellis, 2000; Jordan, 1998).

Women in Rincon &Yates' (2018) study mentioned that they had not really felt that they stood out as a minority female in engineering until they reached the workplace, but this was not universal. Several African American women mentioned

encountering stereotypical racist assumptions in the workplace that brought attention to the fact that they were one of few.

Need to Prove Oneself/ Self-Doubt

Gregory (2015) found that many participants felt pressure to prove themselves to other White counterparts, which created constant worry. One student stated, "Yes, I have the need to prove myself. Being a part of the dual degree program, I want to prove that I can finish. Being a transfer student adds pressure" (pg 75). A second student shared, "My whole collegiate experience I've had to prove myself. I have to prove myself to the Aerospace Engineering department head. I have to prove myself to my family and friends. This is something that I have wanted to do my entire life. I have to prove to myself that I can do it. Why would I want to do something so badly, if it wasn't for me?" (pg 78). Another student stated, "I have to prove that I am smart. I am not here just to fill a quota. I take it upon myself to do a little extra than my teammates. I go above and beyond so that I can have a technical explanation to give to the professor and my teammates. I want them to know that I can do more than scribe" (pg 66). The need to prove their belongingness and "disprove" stereotypical assumptions about African American women were clear illustrations that all ten participants were victims of stereotype threat (Gregory, 2016).

Frillman (2011**)** found that many participants dealt with feelings of self-doubt as the result of an intimidating atmosphere. One student stated, "I think maybe the biggest obstacle was just trying to convince myself that I was capable of the work because at times I would get so down about anything, like, the assignments we had to do. And I was doing really badly on them" (pg 57). Gregory (2015) also found that self-doubt emerged in his study and participants discussed their fear of asking questions in class. Every participant who admitted to being afraid to ask questions in class attributed this fear to them not wanting to appear "stupid". One participant shared, "I think subconsciously I believe I am not as capable as others, and this is probably a stupid question" (pg 70). Another participant suggested, "I can count on my fingers how many times I actually raised my hand to ask questions in lectures. In the back of my mind, I thought, 'I don't want to ask a stupid question. If I ask a question, people are going to look at me like, 'You don't even know that?' I constantly feared that if I asked a question everyone was going to think I was not smart" (pg 76).

Sense of Belonging

Trenor et al. (2008) found that many participants' sense of belonging contributed to positive learning experiences and eased the transition to college for students of all ethnicities. In addition, no major differences were noted across ethnicities in the sense of belonging felt by students in the College of Engineering. Overall, students had a high rate of participation in engineering support programs and other engineering-related associations and resources (Trenor et al., 2008). LaMotte (2016) found that a sense of belonging underscored feelings experienced by the study participants as they participated in their academic environment. The women acknowledged varying levels of social and academic integration and this level helped them determine their sense of belonging in any given situation (LaMotte, 2016). Many researchers found that involvement in activities of the National Society of Black Engineers (NSBE) created a strong sense of belonging. This counter space does not reside within the limits of classroom space and enables African American students to discuss challenges and concerns while bonding with other African American students who share similar cultural backgrounds (LaMotte, 2016). This counter space also allowed the women to affirm the ethnic and/or racial aspects of their identity (Collins, P. H., 2002). NSBE is an external national organization with a mission "to increase the number of culturally responsible Black engineers who excel academically, succeed professionally, and positively impact the community" (NSBE Website, 2016). The presence of NSBE on each of these campuses was important to these women because it served as a place to see familiar faces and where individuals were able to ask for, receive, and provide support (LaMotte, 2016).

Persistence

Frillman (2011) discovered that women's responses indicated that when they needed support they were most likely to reach out to supportive family members, followed by mentoring from organizations, strong role models, a supportive network of classmates, and supportive staff members. Their responses also indicated that they had enjoyed the benefit of mentoring before college.

Passion

Frillman's (2011) participants clearly described passion and explained a sense of responsibility or burden that they felt to give back to the community and the world. For example, one of the participants described her passion for helping animals.

> Um, initially I wanted to do veterinarian medicine. I really love animals. So I don't want to see like, ya know, animals die and go through all that. So I think it would take a toll on my heart, so I decided to stay from that. And I was initially going to do chemistry, but then I decided on chemical engineering because I figured, if I wanted to help animals, then I could just make medicine for them. So, um, just possibly make medicine with my chemical engineering degree, so that's initially why I chose chemical engineering (pg 79).

It was Frillman's (2011) judgment that the participant was describing both her real passion and a sense of purpose in the same statement. Gregory (2015**)** found that all ten participants expressed their desire to encourage and inspire the next generation of engineers, especially those who looked like them. Eight out of ten participants expressed how proud they are to call themselves an engineer, their passion for the work engineers do, and their commitment to earning their degree.

Strong Sense of Self

Frillman's (2011) emergent themes were a strong sense of mission and a sense of purpose. In some cases, the participants had to depend on their own inner resources for emotional support in lieu of receiving it from others, and they showed that they were accepting of the need to do so when necessary (Frillman, 2011). Moreover, the women in this study had an awareness of the need to make a societal contribution using their aptitudes for the sciences and technology.

Gregory (2015) also discovered that participants had a firm identity and strong sense of self. All ten women discussed the importance of having a firm identity and unwillingness to conform. LaMotte (2016) found that motivation emphasized situations, people, and/or opportunities that motivated the women in the study. These motivations originated from their inner goals as well as external sources. The women focused on performing well and obtaining exceptional grades, mastering information, and/or avoiding academic coursework when the subject matter was difficult, and /or the academic environment was chilly and unwelcoming (LaMotte, 2016).

Rice & Alfred (2014) found that participants were determined to succeed. One of the underlying mantras that guided 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. The women were determined to not let obstacles deter them from accomplishing personal success and this mindset served as the defining factor in their perseverance (Rice & Alfred, 2014).

Faith

Gregory (2015) discovered faith, family, and community were important to participants' persistence in engineering. When participants discussed how they were able to persist, most of them mentioned their strong faith, encouragement from their families, and a supportive community, which typically included other Black students on campus (Gregory, 2015). Midgette & Nicole (2014) participants also indicated that their belief in God was a major source of support during their engineering journey. Through God's guidance, participants made decisions about the direction of their lives. In addition, God's guidance provided a life path for participants to follow and relationships developed through church involvement and worship provided support as well (Midgette & Nicole, 2014).

Family

Family and community support were perhaps the most salient and influential factors that African American women identified as encouraging their engineering degree completion (Andersen, M., & Collins, P. H. 2007; Brown, 2000; Carlone & Johnson, 2007; Ellington, 2006; Grandy, 1998; Russell & Atwater, 2005). Russell and Atwater's (2005) research identified three key tenets of parental influence on the African American women scientists in their study: encouragement, acceptance, and educational expectations. A few study participants stated that they had family members who were engineers or worked in technical fields (Rincon & Yates, 2018). Frillman (2011) found that all participants stated that having supportive family members was vital to success. LaMotte (2016) found that most of the women in the study acquired values from their parents and talked about their parents' influence on them and the decisions they made due to that influence. All of the women expressed having the full support of their parents and knowing that their parents wanted them to attend college. Some parents were more specific about educational focus and encouraged their daughters to pursue STEM or more specifically engineering degrees (Frillman, 2011).

Midgette & Nicole (2014) found that participants persisted through college and to degree completion because of their support system, drive, determination, and intrinsic motivation. Researchers also found that family and friends always encouraged participants to strive for their best and to live up to their full potential. In addition, their own intrinsic motivations and drive were integral factors in their persistence; quitting was not an option (Midgette &Nicole 2014). Trenor et al. (2008) found that family members influenced major and career choice in different ways for students of different ethnicities; specific roles varied with parental education level and occupation. Rice & Alfred (2014) also found 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 (Rice & Alfred, 2014).

Student Organizations/Campus Community

Gregory (2015) found that active involvement with the Black community on campus was important among participants. All ten female participants described the importance of being actively involved with student organizations on campus that focused on the needs of African American students. Those most commonly mentioned were the National Society of Black Engineers (NSBE) and organizations dedicated to nurturing camaraderie between Black women, including sororities. LaMotte (2016) found that interaction with administrators in their respective institutions and programs proved to be a positive ingredient in women's academic success. As the women shared their stories, he concluded that some of them did not adopt a sense of belonging in the larger engineering community but were successful in finding smaller peer groups that fulfilled the sense of belonging they required. Most of the women believed their academic environments were more collaborative than competitive, even though some said that the climate began_competitively (LaMotte, 2016).

Sean (2016) discovered that study participants who remained on the fence about the tactical advantages associated with using study groups often cited study groups organized through the National Society of Black Engineers as their sole investment of time in study groups. Whether an academic rock star or a more modest academic performer, participants expressed faith in the desire of the university, faculty, and staff to provide African American students with an experience designed to help them reach both their academic and professional goals (Sean, 2016). In spite of participant perceptions that institutional efforts supporting student success are strong, supplemental insights articulated by students suggested that African American engineering students are conflicted about their academic success and the success of their integration into the culture of the institution and engineering programs (Sean, 2016).

Malcom-Piqueux & Malcom (2015) found that many researchers attributed the success of HBCUs in facilitating STEM Degree attainment among African Americans to the supportive campus cultures and environments of these institutions. For example, in addition to experiencing less social isolation, dissatisfaction, and racism than their Counterparts at PWIs (Perna, 2009;

Jones, Castellanos, & Cole 2002; Pascarella & Terenzini 2003), African Americans found that HBCUs provide a social environment that is more caring, nurturing, and supportive than at non-HBCUs (Fleming, 1984; Nettles, Thoeny, & Gosman 1986; Blackwell, 1998; Redd, 1998; Wagener & Nettles, 1998). The culture of STEM programs at HBCUs has also been found to be more collaborative (Perna et al., 2009) compared to the hypercompetitive culture more common to STEM programs at PWIs.

According to Rincon & Yates (2018), when asked about the type of support received from their universities, over half of those interviewed mentioned the university career centers. They noted that the centers were a key factor in exposure to hiring companies and preparing for professional interviews. Many mentioned the career fairs that occurred, and though only a handful mentioned having gotten their first job through connections made at a career fair, the majority thought that the events were very helpful – particularly for those with little prior work experience (Rincon & Yates, 2018).

Conclusion

This study offers a robust framework for understanding the unique challenges and successes of African American women in engineering education. By meticulously reviewing empirical research and original analyses focused on this demographic, the study not only sheds light on the barriers they face but also identifies opportunities for intervention and support. This knowledge can serve as a blueprint for developing targeted strategies that enhance the persistence and success of African American women in engineering majors. Industry and academia stand to benefit significantly from these insights, potentially leading to a more diverse and innovative engineering workforce capable of addressing broader societal needs. Moving forward, further research should expand upon this foundation to develop tailored frameworks specific to African American women in engineering, empowering higher education institutions to enact meaningful changes in support structures and curriculum design. Ultimately, by investing in the academic and professional success of African American women in engineering, stakeholders can foster a more inclusive STEM landscape that maximizes talent and promotes educational equity on a broader scale.

References

Adam, M. (2013). Researchers look at women of color in STEM fields. *The Hispanic Outlook in Higher Education, 23*, 23–25.

Alter, A. L., Aronson, J., Darley, J. M., Rodriguez, C., & Ruble, D. N. (2010). Rising to the threat: Reducing stereotype threat by reframing the threat as a challenge. *Journal of Experimental Social Psychology, 46*(1), 166–171.

Andersen, M., & Collins, P. H. (2007). *Race, class, and gender: An anthology*. Wadsworth.

Astin, A. W., & Astin, H. S. (1992). Undergraduate science education: The impact of different college environments on the educational pipeline in the sciences. Final Report. Retrieved from https://eric.ed.gov/?id=ED362404

Astone, B., & Nunez-Womack, E. (1991, July). Pursuing diversity: Recruiting college minority students. *ERIC Digest*. Retrieved from http://www.ericdigests.org/pre-9220/diversity.htm

Austin, A. E. (2011). Promoting evidence-based change in undergraduate science education. National Academies National Research Council Board on Science Education. Retrieved fromhttp://dev.tidemarkinstitute.org/sites/default/files/documents/Use%20of%20Evidence%20in%20Changinge%20Undergraduate%20Science%20Education%20(Austin).pdf

Babco, E. (2003). Trends in African American and Native American participation in STEM higher education. *Commission on Professionals in Science and Technology, 1200*.

Beasley, M., & Fischer, M. (2012). Why the leave: The impact of stereotype threat on the attrition of women and minorities from science, math and engineering majors. Retrieved from https://eric.ed.gov/?id=EJ990561

Bell, D. A. (1992). *Faces at the bottom of the well: The permanence of racism*. Basic Books.

Bell, D. A. (1995). Racial realism. In K. Crenshaw, N. Gotanda, G. Peller, & K. Thomas (Eds.), *Critical race theory: The key writings that formed the movement* (pp. 302–312). The New Press.

Bennett, S. (2016). African American student perception of persistence in engineering at a predominantly white institution (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (Publication No. 10116308).

Bonous-Hammarth, M. (2000). Pathways to success: Affirming opportunities for science, mathematics, and engineering majors. *The Journal of Negro Education, 69*, 92-111.

Brown, A. R., Morning, C., & Watkins, C. (2005). Influence of African American engineering student perceptions of campus climate on graduation rates. *Journal of Engineering Education, 94*(2), 263-271.

Brown, S. V. (2000). Testing the double bind hypothesis: Faculty recommendations of minority women fellowship applicants. *Journal of Women and Minorities in Science and Engineering, 6*(2), 207-223.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*, 1187–1218. doi:10.1002/tea.20237

Casey, R. (2012). STEM education: Preparing for the jobs of the future. *US Congress Joint Economic Committee*.

Charleston, L. J., Adserias, R., Lang, N., & Jackson, J. (2014). Intersectionality and STEM: The role of race and gender in the academic pursuits of African American women in STEM. *Journal of Progressive Policy & Practice, 2*, 273–293.

Coger, R. (2012). Why STEM fields still don't draw more women. Retrieved from http://www.chronicle.com/article/Why-STEM-Fields-Still-Dont/135302/

Collins, P. H. (2002). Learning from the outsider within: The sociological significance of Black feminist thought. In C. Lemert & A. Branaman (Eds.), *The Goffman Reader* (pp. 103-130). Wiley-Blackwell.

Collins, P. H., & Bilge, S. (2016). *Intersectionality*. Polity Press.

Conrad, C., Dixson, A., & Green, C. (2014). A discussion on gender, equity, and women of color. *Frontiers, 35*, 3–14.

Crenshaw, K., Gotanda, N., Peller, G., & Thomas, K. (1995). *Critical race theory: The key writings that formed the movement*. New Press.

Crenshaw, K. (2016). Kimberlé Crenshaw: WOW 2016 keynote. On intersectionality [Video file]. Retrieved from https://www.southbankcentre.co.uk/blog/kimberl%C3%A9-crenshaw-wow-2016-keynote.

C. S. Turner, A. L. Antonio, M. Garcia, B. V. Laden, A. Nora, & C. Presley (Eds.), *Racial and ethnic diversity in higher education* (pp. 175-195). Person Custom Publishing.

Dennedhy, T., & Dasgupta, N. (2017). Female peer mentors early in college increase women's positive academic experiences and retention in engineering. Retrieved from www.pnas.org/content/early/2017/05/16/1613117114.full.pdf

Digest of Education Statistics. (2022). Retrieved from http://nces.ed.gov/programs/digest/d12/tables_1.asp

Ellington, R. (2006). Having their say: Eight high-achieving African-American undergraduate mathematics majors discuss their success and persistence in mathematics (Doctoral dissertation). University of Maryland, College Park.

Ellis, E. (2000). Race, gender and the graduate student experience: Recent research. Retrieved from http://www.diversityWeb.org/Digest/FOO/graduate.html

Fleming, J. (1984). Blacks in college: A comparative study of student success in black and white institutions.

Fletcher, T., Ross, M., DeLean, T., James, H., Cardella, M., & Goodwin, A. (2016). Ignored potential: A collaborative roadmap for increasing African American women in engineering. Retrieved from http://www.nsbe.org/getattachment/News-Media/NSBENews/ignored-potential/NSBE-Ignored-Potential-Whitepaper-2-27-17.PDF.aspx

Frillman, S. (2011). A hermeneutic phenomenological study of the experiences of female African American undergraduate engineering students at a predominantly White and an historically Black institution (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (Publication No. 3478456).

Gandhi, C. M. O. (1999). A longitudinal evaluation of factors associated with retaining women in science and engineering. *Dissertation Abstracts International, 60*(11), 5833. (UMI No. 9950087).

Gates, J., & Mirkin, C. (2012). Encouraging STEM students is in the national interest. Retrieved from http://www.chronicle.com/article/Encouraging-STEM-Students-Is/132425/.

George, Y. S., Neale, D. S., Horne, V. V., & Malcolm, S. M. (2001). In pursuit of a diverse science, technology, engineering and mathematics workforce: Recommended research priorities to enhance participation by underrepresented minorities. Retrieved from http://ehrweb.aaas.org/mge/Reports/Report1/AGEP/.

Grandy, J. (1997). Gender and ethnic differences in the experiences, achievements, and expectations of science and engineering majors. *Journal of Women and Minorities in Science and Engineering, 3*, 119-143.

Grandy, J. (1998). Persistence in science of high-ability minority students: Results of a longitudinal study. *The Journal of Higher Education, 69*, 589-620.

Gregory, S. L. (2015). African American female engineering students' persistence in stereotype-threatening environments: A Critical Race Theory perspective (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (Publication No. 4260).

Griffith, A. (2010). Persistence of women and minorities in STEM field majors: It is the school that matters. Retrieved from http://ac.els-cdn.com/S0272775710000750/1-s2.0S0272775710000750-main.pdf?_tid=25defeba-6b43-11e7-8dbd 00000aab0f26&acdnat=1500332360_0f0e421c4840d3bc1d0377dd5b2a9ec1

Hanson, S. (2004). *Swimming against the tide: African American girls and science education*. Temple University Press.

Harper, S. (2007). Nine themes in campus racial climates and implications for transformation. Retrieved from https://www.gvsu.edu/cms4/asset/5D80BD51-996D-6AE0B9D7668ADFEA7A31/nine_themes_in_campus_racial_climates_and_implications_for_institutional_transformation.pdf

Hill, C. (2017). *Why so few? Women in science, technology, engineering and mathematics*. http://www.aauw.org/research/why-so-few/

Hurtado, S. (2003). Institutional diversity in American higher education. In S. R. Komives & D. B. Woodward (Eds.), *Student services: A handbook for the profession* (pp. 23-44). Jossey-Bass.

Ireland, Freeman, Proctor, Delaine, Lowe, & Woodson (2018). Un)Hidden Figures: A Synthesis of Research Examining the Intersectional Experiences of Black Women and Girls in STEM Education. Retrieved from http://journals.sagepub.com/doi/abs/10.3102/0091732X18759072

Johnson-Bailey, J. (2001). *Sistahs in college: Making a way out of no way*. Krieger.

Johnson, D. (2012). Campus racial climate perceptions and overall sense of belonging among racially diverse women in STEM majors. Retrieved from https://muse.jhu.edu/article/469349/pdf

Johnson, D. J., et al (2022). COLLEGE WOMEN OF COLOR: INTERSECTIONALITY, RESILIENCE, RESISTANCE, AND EMERGING ADULTHOOD. *Research in Human Development, 19*(3–4), 61–74. https://doi.org/10.1080/15427609.2023.2168591

Jordan, K., & Sorby, S. (2014). Intervention to improve self-efficacy and sense of belonging of first-year underrepresented engineering students. Retrieved from https://www.asee.org/public/conferences/32/papers/9514/download

Joseph, J. (2012). From one culture to another: Years one and two of graduate school for African American women in the STEM fields. *International Journal of Doctoral Studies, 7*, 125–142.

Keith, J., Ayer, D., Rees, E., Freda, D., Lowe, J., & Day, J. (2003). Brief of Amici Curiae Massachusetts Institute of Technology, Leland Stanford Junior University, EI Du Pont de Nemours and Company, International

Business Machines Corp., National Academy of Sciences, National Academy of Engineering, National Action Council for Minorities in Engineering, Inc., in Support of Respondents in the Supreme Court of the US (Grutter v. Bollinger and Gratz v. Bollinger). *Grutter v. Bollinger, et al, (02-241)*.

Kolo, Y. (2016). Experiences of African American young women in science, technology, engineering, and mathematics (STEM) (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. Publication No. 9085456.

Ladson-Billings, G. (2013). "Stakes is high": Educating new century students. *The Journal of Negro Education, 82*, 105–110.

LaMotte, E. (2016). Unique and diverse voices of African American women in engineering at Predominately White Institutions: Unpacking individual experiences and factors shaping degree completion (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. Publication No. 350087.

Langford, G. (2014). Minorities in STEM: Past, present and future. Retrieved from http://www.huffingtonpost.com/george-m-langford/minorities-in-stem-past-present-and-future_b_4876784.html.

Landivar, L. (2013). Disparities in STEM employment by sex, race, and Hispanic origin. Retrieved from https://www.census.gov/prod/2013pubs/acs-24.pdf.

Lathrop, J., & Dasgupta, N. (2017). Female peer mentors help retain college women in engineering. Retrieved from http://www.spsp.org/news-center/press-releases/engineermentor-women.

Leaper, C., Farkas, T., & Brown, C. S. (2011). Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English. *Journal of Youth and Adolescence*, *41*, 268–282. doi: 10.1007/s10964-011-9693-z.

Lynch, M. (2014). Diverse conversations: Recruiting a diverse student population. Retrieved from http://diverseeducation.com/article/60394/

Malcom, S. M., Hall, P. Q., & Brown, J. W. (2011). *The Double Bind: The Price of Being a Minority Woman in Science* (pp. 1-79).

Malcom, L., & Malcom, S. (2011). The double bind: The next generation. *Harvard Educational Review, 81*, 162–171.

Malcom-Piquex, L., & Malcom, S. (2015). *African American women and men into engineering: Are some pathways smoother than others?* Johns Hopkins University Press. Retrieved from Project MUSE database. https://muse.jhu.edu/book/42522

Massey, W. (2005). A success story amid decades of disappointment. *Science, 258*(5085), 1177-1179.

Marx, D. M., & Stapel, D. (2006). It depends on your perspective: The role of self relevance in stereotype-based underperformance. *Journal of Experimental Social Psychology, 42*, 768–775.

McGee, E. O. (2005). Chronicles of success: Black college students achieving in mathematics and engineering. Retrieved from https://blacksuccessfoundation.org.

McGee, E. O. (2009). Race, identity, and resilience: Black college students negotiating success in mathematics and engineering (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (Publication No. 3364621).

McGee, E. O., & Martin, D. B. (2011). You would not believe what I have to go through to prove my intellectual value! Stereotype management among academically successful black mathematics and engineering students. *American Educational Research Journal*, *48*(6), 1347-1389.

Midgette, S., & Nicole, K. (2014). An engineering journey: A transcendental phenomenological study of African American female engineers' persistence (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (Publication No. 560987654).

Miller, L. (2003). *Reaching the Top: Report of the National Task Force on Minority High Achievement*. The College Board.

National Academy of Engineering, and Institute of Medicine. (2007). *Rising above the gathering storm: Energizing and employing America toward a brighter economic future*. National Academies Press.

National Science Foundation. (2008). *Women, minorities, and person with disabilities in science and engineering*. National Academies Press.

National Science Foundation. (2010). *Women, minorities, and person with disabilities in science and engineering*. National Academies Press.

National Society of Black Engineers. (2016). Mission statement retrieved from http://www.nsbe.org/About-Us/NSBE-Vision-Mission-Objectives.aspx#.VrFx5lJSars.

Ong, M. (2010). *The Mini-Symposium on Women of Color in Science, Technology, Engineering, and Mathematics (STEM): A Summary of events, ndings, and suggestions*. TERC.

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review, 81*, 172–204.

Perna, L., Lundy-Wagner, V., Drezner, N. D., Gasman, M., Yoon, S., Bose, E., & Gary, S. (2009). The contribution of HBCUs to the preparation of African American women for STEM careers: A case study. *Research in Higher Education, 50*, 1–23. doi: 10.1007/s11162-008-9110-y.

Penrice, R. (2017). Facing racism and sexism: Black women in America. Retrieved from http://www.dummies.com/education/history/american-history/facing-racism-and-sexism-black-women-in-america/.

Rice, D., & Alfred, M. (2014). Personal and structural elements of support for African American female engineers. Retrieved from http://jstem.org/index.php/JSTEM/article/view/1843.

Rincon, R., & Yates, N. (2018). Women of color in the engineering workplace. Retrieved from http://www.nsbe.org/getmedia/b01e0f12-9378-46b0-ad4d-a0f513b947a5/Women-ofColor-Research-2018.aspx.

Rumrill, P. D. Jr., & Fitzgerald, S. (2001). Using a narrative literature review to build a scientific knowledge base. Retrieved from https://doresearch.wordpress.com/tag/narrative-review/.

Samuelson, C. C., & Litzler, E. (2016). Community cultural wealth: An assets-based approach to persistence of engineering students of color. *Journal of Engineering Education*, *105*, 93–117.

Seibt, B., & Förster, J. (2004). Stereotype threat and performance: How self-stereotypes influence processing by inducing regulatory foci. *Journal of Personality and Social Psychology, 87*(1), 38.

Shain, C. H. (2002). Revisiting the problem of engineering school persistence in African-American women students (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (Publication No. 304798888).

Shapiro, J. R., & Neuberg, S. L. (2007). From stereotype threat to stereotype threats: Implications of a multi-threat framework for causes, moderators, mediators, consequences, and interventions. *Personality and Social Psychology Review*, *11*, 107-130.

Slaughter, J. B., Tao, Y., & Pearson, J. W. (2015). Changing the face of engineering: The African American experience. Johns Hopkins University Press. Retrieved from Project MUSE database. https://muse.jhu.edu/book/42522.

Steinmetz, S., & Braham, C. (1993). *Random House Webster's dictionary*. Ballantine Books.

Thomas, T. C., & Thurber, H. J. (1999). Strategies for the recruitment and retention of Native American students: Executive summary. Educational Document Reproduction Service No: ED435514.

Trenor, J., Shirley, Y., Consuelo, W., Katherine, Z., & Ting-Ling, S. (2008). The relations of ethnicity to female engineering students' educational experiences and college and career plans in an ethnically diverse learning environment. Retrieved from https://www.inesweb.org/files/Trenor%20et%20al%20JEE%202008.pdf

U.S. Bureau of Labor Statistics. (2015). STEM crisis or STEM surplus? Yes and yes. Retrieved June 02, 2016, from http://www.bls.gov/opub/mlr/2015/article/stem-crisis-or-stem-surplus-yes-and-yes.htm.

U.S. Department of Education. (2006). A test of leadership: Charting the future of U.S. higher education. Retrieved from http://www.ed.gov/about/bdscomm/list/hiedfuture/reports/final-report.pdf.

U.S. Department of Education. (2012). Data point: Postsecondary enrollment before, during, and since the great recession. Retrieved from http://nces.ed.gov/pubs2013/2013156.pdf.

U.S. Department of Education. (2013). Digest of education statistics, 2012. Retrieved from http://nces.ed.gov/programs/digest/d12/tables_1.asp

U.S. Department of Education. (2015). Digest of education statistics, 2014. Retrieved from http://nces.ed.gov/programs/digest/d14/tables/dt14_318.20.asp.

U.S. Department of Education. (2022). Digest of education statistics, 2022. Retrieved from https://nces.ed.gov/programs/digest/d17/tables/dt17_318.20.asp.

Valian, V. (1999). *Why so slow? The advancement of women*. MIT Press.

Wachter, R. M. (2003). A selective literature review of women, minorities, and educational resources in science and engineering. Retrieved from http://www.diversityweb.org/digest/sp303/selective.cfm.

Wages and Salaries. (2014). Retrieved from https://www.census.gov/library/publications/2015/demo/p70-141.html.

Washington, M. (2013). Breaking stereotypes: Developing a model for minority success in engineering (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (Publication No. 3576896).

Williams, D., Berger, J., & McClendon, S. (2005). Toward a model of inclusive excellence and change in postsecondary institutions. *Washington, DC: Association of American Colleges and Universities*.