



IGNORED POTENTIAL

A COLLABORATIVE
ROAD MAP FOR INCREASING
AFRICAN-AMERICAN WOMEN
IN ENGINEERING



NATIONAL SOCIETY
OF BLACK ENGINEERS



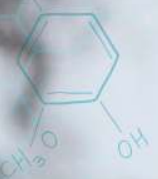
$$(x-1)\left(x+3+\frac{3}{x-1}\right) = \left(\frac{4-x}{x-1}\right)(x-1)$$

$$(x-1)(x+3)+3=4-x$$

$$x^2+2x-3+3=4-x$$

$$x^2+3x-4=0$$

$$(x-1)(x+4)=0$$



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WHO WE ARE

With 278 chapters and nearly 16,000 active members in the U.S. and abroad, the **National Society of Black Engineers (NSBE)** is one of the largest student-governed organizations based in the United States. NSBE, founded in 1975, supports and promotes the aspirations of collegiate and pre-collegiate students and technical professionals in engineering and technology. NSBE's mission is "to increase the number of culturally responsible black engineers who excel academically, succeed professionally and positively impact the community." For more information, visit www.nsbe.org.

The mission of the **Society of Women Engineers (SWE)** is to "stimulate women to achieve full potential in careers as engineers and leaders, expand the image of the engineering profession as a positive force in improving the quality of life, and demonstrate the value of diversity." SWE strives to value diversity including race/ethnicity, family status, age, physical abilities, sexual and affectional orientation, actual or perceived gender, gender identity and expression, socio-economic status and occupational focus. Through active outreach, SWE works to develop women in engineering at all levels of socioeconomic status; encourages interest and active participation of girls from underrepresented groups, including African-American women; and provides support to women which acknowledges differences rather than treating women as a monolith.

Women in Engineering ProActive Network (WEPAN) works to propel higher education to increase the number and advance the prominence of diverse communities of women in engineering. WEPAN serves as a source of resources for faculty, leaders, and staff in higher education and corporate partners to promote women and provide research-based approaches for improving the climate of these areas for all women. One of WEPAN's foundational goals is that "diversity builds excellence." This statement highlights WEPAN's commitment to the inclusion of more women in engineering to improve the quality of the field and promote access and equity for these women.

Purdue University's School of Engineering Education includes faculty, staff and students who oversee and teach courses within Purdue's First-Year Engineering program; Purdue's undergraduate Interdisciplinary Engineering Studies program; and Purdue's graduate program in Engineering Education. Researchers in the School of Engineering Education examine student learning of engineering concepts, pedagogical approaches for engineering, methods for assessing engineering, and patterns in who participates (and who does not participate) in engineering across the lifespan—from preschool to professional practice. The School is committed to promoting diverse participation in engineering and engineering education.

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By 2020, STEM jobs in the United States are expected to increase by 10% (Lockard & Wolf, 2012); however, with some sectors reporting nearly 600,000 unfilled engineering jobs (BLS, 2015), declining numbers of engineering graduates cause alarm. The dearth of African American students in engineering is often cited as a crucial area for improvement, but upon closer examination, African American *women* in particular are pursuing engineering degrees at lower rates; in fact, only 26.3% of engineering bachelor's degrees awarded to African Americans in 2011 went to women despite the fact that women outnumber men nearly 2 to 1 in college (Slaughter et al, 2015). Literature often focuses on African American students compared to white students or women compared to men, but few seek to address the unique challenges faced by African American women. By focusing specifically on this population, industry and academia may better understand how to diversify the workforce, leading to more sustainable engineering innovations (Keith et al. 2003; Wulf 1988) and solutions that appeal to a broader base of the population (Miller, 2003; U.S. Department of Education, 2010).

CURRENT STATE OF AFRICAN AMERICAN WOMEN IN ENGINEERING

According to the American Society for Engineering Education, African Americans only received 4.0% of engineering degrees awarded in 2015, down from 5.0% in 2006. (See Figure 1 on next page.)

What contributes to the decline of African Americans graduating with engineering degrees? Data show that African American women in particular are pursuing engineering degrees three times less often than their male counterparts (Slaughter et al, 2015). According to NACME's assessment of the National Science Foundation's IPEDS system, approximately 1,100 African American women graduated with an engineering degree in 2005. By 2011, only 809 graduated with a bachelor's degree in engineering, an

approximate 27% decrease (NACME, 2013). In 2015, less than 1% of all U.S. engineering bachelor's degrees were awarded to African American women (Yoder, 2016).



Understanding why African American women are underrepresented in engineering requires a systems perspective. "Diversity" is not a monolithic construct; the ways in which different underrepresented groups experience engineering are not the same, and groups with multiple identities also have unique experiences with participation in engineering. African American women have unique experiences that stem from their identity both as African Americans and as women. The experiences of women in general do not necessarily equate to those of African American women. Therefore, a sole focus on women in engineering does not begin to uncover the challenges faced by African American women.

In addition to exploring the challenges and barriers faced by African American women, we must also acknowledge and seek to better appreciate the valuable experiences and knowledge African American women bring to engineering. Highlighting their distinctive contributions and attributes would challenge implicit and explicit deficit orientation in which this demographic is often framed. A focus on deficiencies that is common in research and

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Black or African American	5.0%	4.9%	4.7%	4.6%	4.5%	4.2%	4.2%	4.3%	3.5%	4.0%
Hispanic	6.0%	6.2%	6.5%	6.6%	7.0%	8.5%	9.0%	9.3%	10.1%	10.7%
Other	8.5%	8.3%	8.9%	11.0%	1.2%	1.6%	2.0%	2.3%	2.9%	3.1%
Asian American	13.8%	13.3%	13.0%	12.4%	12.2%	12.2%	12.2%	12.9%	13.1%	13.4%
White	66.7%	67.3%	66.9%	65.4%	68.9%	66.6%	66.2%	65.7%	65.9%	64.9%
Unknown					5.3%	6.9%	6.4%	5.6%	4.9%	3.9%

Figure 1: Bachelor’s degrees awarded by ethnicity between 2006 and 2015 (Yoder, 2016)

programmatic efforts can lead to a one-sided representation, which is often perpetuated by media and impacts the way the educational system prepares African American female students. Instead, we need to also focus on the skills, perspectives and resources that African American Women bring to engineering and engineering education.

We – NSBE, SWE, and WEPAN – commit to promoting an anti-deficit view of the participation of African American women in engineering that recognizes African American women as unique from “women” and “African Americans;” we invite the larger community to join us in this work as well. Therefore, this paper is a synthesis of interventions, research and collaboration which address systemic factors that lead to the underrepresentation of African American women in engineering while accounting for the intersectionality of being an African American woman in engineering from a lens that does not view them as having deficiencies or simply filling a need.

AFRICAN AMERICAN WOMEN ≠ AFRICAN AMERICANS + WOMEN

Since the dawn of the Civil Rights Movement, there has been a continuous need to address inequity in education and the workplace. However, these initiatives designed to address women and persons of color pose somewhat of a challenge for those who fit into both categories. Programs for people of color and programs for women exist under the assumption that they include women of color, but African American women are often lost between the two. Women of color face the challenges of gendered racism quietly, as their experiences are typically a footnote or byline in scholarly research and analysis (Blake, 1999). It is often the assumption that the study of men of color includes women of color. Likewise, studies of majority women are assumed to reflect the experiences of their minority counterparts. Both assumptions render the woman of color invisible (Blake, 1999).

Intersectionality examines the connections between social constructs of race, class, and gender (Crenshaw, 1991). Often in quantitative education research, averages of students or student groups are reported as a monolith. For example, studies report on women compared to men or on black students compared to white students. However, the results of such comparisons are not additive, for combining the outcomes of women with black students does not equal the outcomes of black women (Hancock, 2007). To address this issue, the intersections of race and gender will be examined.



Women of color are at the intersection of two of the most pervasive prejudices in this country: racism and sexism (Blake, 1999). Ferdman (1999) stated that existing research that evaluates the unique effects of race and gender treat them as separate and distinct variables. This implies that racial and gender components of identity can be compartmentalized and operate independent of each other. There is a gap in the research when it comes to examining the intersectionality of race and gender as it pertains to STEM persistence in industry. Race and gender have a confluent effect on the informal social systems that exist in industry and subsequently impact career advancement for women of color (Combs, 2003). The way national databases are structured contributes to this virtual invisibility; women of color tend to disappear among aggregates of all women, or all members of a particular ethnic group. Trying to separate them, in most cases, is not trivial, especially in industry (Maclachlan, 1997).

SYSTEMIC FACTORS

Researchers cite several systemic factors that work against the participation of African American women in engineering (Obiomon et al, 2007; Foor et al, 2007). Lack of visible role models in engineering, stereotype threat, biculturalism, tokenism, feelings of isolation, and pay inequities in the engineering workforce are all factors at play. Black women in engineering must put in additional effort to overcome these unique challenges that occur at the intersection of racial and gender inequality.

Role models: Role models are effective in “helping students connect their personal identities to engineering identities” (Matusovich, Streveler & Miller, 2010), because they allow individual students to imagine themselves as engineers. However, since women and minorities are underrepresented in engineering, role models are rare for most African American females. Researchers acknowledge that the dearth of African American females in engineering education perpetuates the scarcity of role models for aspiring engineers (Obiomon et al, 2007).

Stereotype threat: In her 2015 book, DeOrnellas (2015) describes a young woman’s experience as a computer science intern and explores the effects of stereotype threat on her first job. Stereotype threat is a

situational predicament in which an individual feels at risk of conforming to negative stereotypes about their social group (Steele & Aronson, 1995, p. 797). This well-documented phenomenon affects the performance of people in a variety of situations. For stereotype threat to occur, an individual must identify with a group of people that carries a well-known stereotype and must care about the outcome of her performance. High-performing women and minorities (e.g. Black, Latino/a, and Native American populations) have demonstrated the effects of stereotype threat on math and verbal exams of high cognitive difficulty. Underperformance on standardized exams is attributed to fear of reinforcing negative stereotypes about their race and gender (Steele, 2010). DeOrnellas’ subject described an “[...] intense self-awareness [that] interfered with her work and her learning” (DeOrnellas, 2015). She was worried that she might say or do something that would confirm perceived existing stereotypes.

Biculturalism: Women of color are implicitly expected to behave differently at work and at home; this leads to managing the contexts of both European American and African American culture (Obiomon et al, 2007). Forming a bicultural life structure puts a person in a position of marginality. A marginal person is one who lives on the boundary of two distinct cultures, one being more powerful than the other, but who does not have the ancestry, belief system, or social skills to be a full member of the dominant group (Bell, 1990). The moment African Americans enter a predominately white organization, there is a pressure to disprove preconceived stereotyping. Many African Americans feel like they have to say the right thing, not say too much, or agree just to fit in (Obiomon et al, 2007).

Tokenism: A token is defined as a minority person that is integrated into the majority group through policy or practice in an attempt to desegregate. Research reported by Obiomon et al (2007) on stressful environmental factors revealed that



underrepresentation leads to high visibility and sets into place a variety of negative perceptions of persons labeled as tokens. When an African American is perceived as a token by majority group employees, their behavior and job performance, whether good or bad, is magnified, exaggerated and unduly scrutinized (Obimon et al, 2007). Malcolm et al (1976) reported that token women of color were expected to perform auxiliary functions not directly related to their jobs, such as leading committees concerned with women and/or minority interests, recruiting, and completing administrative tasks associated with special programs for minority group members. Ironically, employers reportedly looked less favorably upon race or gender-related activity (Malcom et al, 1976).

Feelings of belonging or isolation: Several studies cite students from underrepresented groups feeling like they do not belong in engineering (Foor et al, 2007; Geisinger & Raman, 2013; Seymour & Hewitt, 1997). To become an engineer, one must be exceptionally smart and proficient in math and science, according to conventional wisdom. In Carol Dweck's work, the belief that individuals either have an aptitude for something or do not is called a "fixed mindset" and can be detrimental to student success (Dweck & Sorich, 1999). If our culture repeatedly propagates messaging that black female students are not naturally good at subjects like math and physics, those students come to believe this is true. To remedy this, authors of a piece in *The Economist* recommend a "[...]cultural shift in schools and universities, playing down talent and emphasizing hard work, might serve to broaden the intake of currently male-dominated and black-deficient fields, to the benefit of all" ("Sex differences," 2015).

No matter how the numbers are reported the fact remains that a woman of color is still very likely to be the only minority woman in many STEM departments in the United States. She may not be the first woman of color in a particular department, but she will likely still experience much of the isolation and scrutiny reserved for the very first woman of color (Maclachlan, 1997, p.3). This isolation is a common theme found in industry and academia, particularly on predominately white college campuses. Women of color felt socially ostracized, and they reported experiencing emotional pain from social isolation (Allen, 1992, p. 30). Furthermore, African American women are often excluded from networks and isolated in the work

environment. One reason can be attributed to racial visibility. Women of color stand out because of hair, skin, and body shape (Obimon et al, 2007). Being "the only one" or one of a few coupled with self-doubt from the absence of role models can be taxing. Women who are isolated are 13% more likely to report being unsatisfied in their jobs, and those unsatisfied women are 22 times more likely to leave (Ashcraft & Blithe, 2010).

Pay inequities: Currently, pay inequity discussions dominate the national conversation sparking headlines like, "Engineer took all the right steps but still didn't receive fair pay," (AAUW, 2013) describing the story of a black woman feeling the financial burden of her dual-minority identity in engineering. It was her new, white female manager that brought the pay disparity to her attention. Her manager attempted to narrow the pay gap by submitting a pay increase that was denied and one year later, the woman was terminated (AAUW, 2013). Her claims are substantiated by Wallace's 2014 report showing that white women make 78% of white men's salaries, while Black women make 64% (Wallace, 2014). Most arguments against pay equity legislation are fueled by incongruity in education and career selections, but the woman in the story had undergraduate and graduate degrees in electrical engineering. Neither insulated her from the pay inequity resulting from racism and sexism.



THE ANTI-DEFICIT APPROACH

Many efforts to provide support for African American women focus on improving "deficits" in students rather than on issues within the education system. Intervention research often covers lack of family support, poor academic preparation, and low test scores; suggestions focus on fixing what is broken about students rather than the systems in which they operate. We argue that research and education should adopt an anti-deficit approach, or one that focuses on the system as a whole as opposed the

shortcomings of the individual, to move past one-dimensional thinking and promote student differences that can enhance engineering. Yosso (2005), for example, introduced community cultural wealth (CCW) to the research community providing a different lens with which to view non-normative populations (i.e., black women). Researchers are challenged to identify, evaluate, and present the wealth that black women bring to the engineering community including but not limited to: aspirational, navigational, social, familial, and resistant capital. Aspirational capital refers to a black woman's ability maintain hope and dreams despite obstacles and barriers. Navigational capital speaks to a black woman's ability to maneuver through social institutions, arguably because of their standpoint. Being a black woman, they possess the insight of how others view them. Social capital refers to the use of the vast array of resources (e.g., community centers, church groups, etc.) or networks that can be used for gaining access to various opportunities (e.g., scholarships, internships, etc.). Familial capital describes the ways in which black women "[...] carry a sense of community history, memory, and cultural intuition" with them (Yosso, 2005, p. 79). And most importantly, resistant capital referring to the knowledge acquired through "[...] oppositional behavior that challenges inequality" (Yosso, 2005, p. 80). Despite systemic opposition, some black women do become engineers and they come with capital.

HOW CAN WE CHANGE THE CONVERSATION?

To encourage systematic change that values the contributions and encourages the participation of African-American women in STEM fields, we offer a set of recommendations to key stakeholders.

Professional Organizations

- **Joint memberships:** Provide support for joint membership in organizations that have meaningful intersections, especially those described in this white paper. For example, NSBE and SWE offer a joint membership at a discount to their members. Joint membership could be a baseline target. Moving beyond this baseline, groups can leverage joint collaborations in other areas, including programming, outreach and activism efforts, and collaborations with other institutions (schools, community centers, etc.).
- **Join forces:** Collaborate with researchers and higher education to implement evidence-based programming.
- **Targeted programming:** Professional organizations can provide opportunities within their annual meetings for researchers to highlight work that utilizes an achievement-based framework rather than a deficit framework. Co-sponsored events and joint programming at the larger events of engineering societies would demonstrate that multiple identities of African American women can coexist. In addition to the anti-deficit framework, professional organizations should consider including programming that acknowledges multiple dimensions of the individual and programming that highlights systemic factors as part of the regular ongoing activities. (For a great example, see <http://www.aas.org/news/women-s-history-month-eight-books-sbf-archives>.)
- **Publicized outreach:** Professional organizations can provide information on how members can get involved in service work, advocacy, and other educational opportunities related to issues that affect them personally.
- **Celebrate existing talent:** Professional organizations can highlight the success stories of their own members who can serve as intersectional role models to other individuals within the organization. Networking events, awards, and newsletter articles can provide a space for African American women to connect.

Engineering Industry

- **Partnerships:** Industry can continue to partner with organizations like NSBE, SWE, and WEPAN through support of K-12 and collegiate initiatives to increase interest and persistence, respectively, in STEM. Additionally, the development of affinity groups within engineering companies will create networking opportunities for like individuals.
- **Hiring efforts:** Industry can be deliberate in hiring efforts through active recruitment at historically black colleges and universities (HBCUs), which graduate the most African American women

engineers. Engineering firms can also consider hiring in cohorts, creating an instant network of new hires.

- **Mentoring:** Active mentoring initiatives would encourage networking and create stronger feelings of belonging among employees. Beyond the workplace, employees can reach out to local schools to mentor K-12 students.
- **Diversity and inclusion training:** Though most companies have some sort of etiquette training in the HR onboarding phase, training that equips employees with the means to recognize their own stereotypes and biases would help to create a safe space for those who may feel undue pressure.
- **Process improvement measures:** Companies should re-evaluate data reporting methods to include intersectionality so that African American women become visible in attrition metrics. Additionally, hiring and promotion processes should be reviewed to ensure that the company offers fair salaries and opportunities. Adjustments should be made accordingly if discrepancies are detected.

Policy Makers

- **Public recognition and consultation:** Policy makers can identify and recognize individuals and institutions that are making strides in advancing African American women in engineering. When crafting new initiatives that directly affect that population, those exemplary individuals/representatives of institutions should be invited to participate in the conversation.
- **Forge partnerships:** Support cross-cutting efforts to alleviate inequities and promote interdisciplinary work, alongside other institutions/universities (e.g., <http://www.purdue.edu/newsroom/releases/2015/Q1/purdue-joining-national-effort-to-attack-grand-challenges.html>).
- **Establish a standard for data:** Seek to utilize and promote the gathering of data that can be cross-tabulated by important intersectional factors. In conjunction with researchers, policy makers can highlight data that applies an anti-deficit framework and is relevant to the systemic factors that this white paper outlines.

- **Even the playing field:** Set policy to ensure that all schools provide opportunities for students to learn calculus.

Higher Education

- **Make diversity a priority:** Colleges of engineering must ensure that diversity is a priority in every department. Leveraging the professional societies and organizations (such as NSBE and SWE) will help build sustainable communities of women of color within engineering.
- **Promote community:** Establish and support a community of faculty members who are known to mentor young African American women faculty, graduate students and undergraduate students. Recognize and reward those high-performing faculty members to ensure that the cycle continues.
- **Foster understanding:** Develop a culture of understanding and valuing ethnic differences in the college of engineering amongst faculty, staff and students. This may include diversity and inclusion training, guest lectures from engineers of color, or small group discussions where students are encouraged to share their cultural experiences as they relate to engineering.
- **Collaborate with other learning institutions:** Work with community colleges and K-12 schools to ensure smoother transitions and a more cohesive K-16 learning experience.
- **Consider cohort models:** For example, admit cohorts of students who have already developed a strong network of support.

K-12 Schools

- **Create a holistic environment for learning:** Make engineering approachable for teachers and students. Encourage the development of extracurricular programming that promotes engineering learning. Connect with community organizations. Use proven methods for introducing teachers to practices for integrating engineering concepts in existing curricula.
- **Teacher training:** Help teachers understand, identify and address biases, unconscious attitudes,

and prejudices towards African American girls, particularly those interested in pursuing technical careers. These may implicitly affect teaching styles.

- **Use affirmation:** Create school environments that affirm African American girls, developing their STEM identity and their STEM exploration.
- **Provide counselors with targeted resources:** Inform school counselors about career pathways to engineering, scholarships available for minority women pursuing engineering degrees, and course plans that best enable students to easily transition into college engineering programs.

Parents and Families

- **Help girls develop resilience:** The culture of engineering is undergoing change but some environments may still not be comfortable for girls with emerging interests in STEM. Parents and guardians should seek to affirm their daughters' skills, knowledge, attributes, abilities, and blossoming engineering identity.
- **Identify STEM resources to promote early exposure:** Look for opportunities for girls to engage in STEM learning, such as summer camps and after-school clubs. This will help to build confidence in STEM subjects early in a young girl's academic career. Organizations like the Khan Academy offer free online resources that promote STEM learning. Here are links to a few resources that may be helpful:
 - WEPAN strategic initiatives: <http://www.wepan.org/?page=528>
 - NSBE information for parents and educators: <http://www.nsbe.org/Parents-and-Educators/Home.aspx>
 - SWE's recommendation for parents: <http://www.engineergirl.org/>
 - Amy Poehler's smart girls: <http://amysmartgirls.com/celebrate-black-history-month/>
 - Black Girls Code: <http://www.blackgirlscode.com/>
 - Purdue's INSPIRE Research Institute for Pre-College Engineering: <https://engineering.purdue.edu/INSPIRE>

- **Make STEM part of recreational time:** From visiting free science museums to crafting do-it-yourself projects and 3D printers, there are endless ways for parents to spend time with their daughters in diverse STEM environments.

Faith- and Community-based Organizations

- **Educate the community:** Seek partnerships with local industry, university and professional engineering organizations to raise community awareness for engineering. This can include hosting "Family Engineering Nights" or simply providing resources that promote efficacy in mathematics and science from an early age.
- **Advocate for change:** Community organizations should consider partnering with other organizations to co-sponsor legislation regarding educational policies around funding.
- **Relate engineering to core values:** While promoting core values and beliefs, community organizations can demonstrate how engineering exemplifies those principles (e.g., understanding other's needs, responsibility to the community, value for people different than themselves).
- **Affirmation:** As with other stakeholders, community organizations should affirm and promote a positive self-identity among African American women and girls.

Researchers

- **Consider intersectionality, anti-deficit, systemic factors:** Researchers can utilize the anti-deficit framework provided here (or others like it) to reframe research approach. This may entail thoughtful revisions of choice of variables to include, grouping of data, and construction of research framework.
- **Collaboration:** Work with policymakers and other groups to disseminate work to the broader public
- **Focus specifically on African American women:** There is critical need for more peer-reviewed publications and more readily available data associated



with the barriers of women of color in industry. Being able to cite sources and articulate data about underrepresentation elevates credibility when pushing forward on issues like cultural isolation or barriers to success (Ong, 2010). Dedicating research to women of color would help assess the root causes of attrition, identify gaps in existing research and recommend strategies for improving upon programmatic, institutional, and nationwide efforts.

CONCLUSION

To truly enhance contributions from women of color, we as stakeholders must invest in them at all stages in their academic and professional careers. We must also invest in systems that value African American women and their contributions. This set of recommendations provided is by no means exhaustive; rather, it is intended to spark a conversation on how to increase the participation of African American women in engineering. Approaching the problem from multiple perspectives is necessary, as there is no 'silver bullet.' Instead, systemic change will come from **collaboration**, which will empower each of us to make an impact through shared knowledge and support of a community.



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