Chapter 9
Challenges of Overcoming Structural Barriers for African American Engineers in the United States and in the African Diaspora

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Abstract This chapter outlines the academic literature that addresses the persistent underrepresentation of African Americans in engineering education in the United States and throughout the African diaspora. While the numbers of African Americans has grown over the past few decades in other professions, the numbers of African Americans in engineering have stagnated and declined since the beginning of the twenty-first century. Early pioneers of scholars in African American studies thought that they could easily construct a reverse mirror image of the curricula they encountered in other academic disciplines, such as history, political science, or anthropology. A glaring omission of the early pioneers is the work that would be needed in engineering education. Many of the early pioneers failed to take into account that work needs to also be done *directly within* engineering education to foster "socio-technical" engineering undergraduates and professionals. The depoliticization and meritocratization of engineering education has often allowed structural barriers to remain in place that hinder the success of African Americans in engineering. After summarizing some of the major explanations that attempt to explain underrepresentation of African Americans in engineering, the article concludes with suggestions for further research, highlighting the continued pivotal role of historically black colleges and universities and the need to encourage more investments to promote research and development in African universities.

Keywords African Americans • Sub-Saharan Africa • Historically black colleges and universities (HBCUs) • Engineering education • Underrepresentation • Science • Technology • Engineering • Math (STEM)

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Introduction: The Persistent Underrepresentation of African Americans and People of African Ancestry in Engineering

The African diaspora is defined to include peoples of sub-Saharan ancestral origins[1] on the continent of Africa, the Caribbean, the Americas, and worldwide. This diaspora began to emerge with the advent of the slave trade in the 1500s. Over the centuries, people of African ancestry have been able to enter other professions such as theology, law, social services, and business. However, engineering as a profession of choice and pursuit for people of African ancestry has been underrepresented than these other professions.

According to Mark Matthews, "sixty years after the Supreme Court outlawed segregated school systems in the United States, de facto racial imbalances persist in American education" (Matthews 2014). One particularly salient example is the underrepresentation of African Americans in engineering. While there is consensus of disapproval of this reality, there is no single reason that explains it (Matthews 2014). For African American men, the situation is further compounded by their overall position in higher education, where they are regularly outperformed and outnumbered by African American women. Underrepresentation of African Americans in engineering will continue to be salient as trends point in the direction of dismantling affirmative action programs, such as when the U.S. Supreme Court's ruled in the 2003 *Gratz v. Bollinger* case that the point system used by the University of Michigan for undergraduate admissions was unconstitutional. With seven other states with similar bans and others likely to follow, creative new tools will need to be implemented to enroll and retain African Americans in engineering programs in the United States (Matthews 2014).

Some of the remedies suggested are (1) recognizing that it may take five years for undergraduates to attain their engineering degrees; (2) summer bridge programs that have strong developmental teaching and conscientious advising; (3) designing lab and classroom settings that foster a welcoming setting for African Americans and other under-represented minorities in engineering environments; and (4) understanding mentors who can make a difference and provide the support to retain African Americans in engineering programs as opposed to giving up in despair (Matthews 2014).

However, a more basic set of questions have been raised to explore the assumptions of engineering education. As Caroline Baillie notes, "engineers are often not encouraged to consider *who* they engineer *for*" (Baillie 2006). As a recent UNESCO

[1] To be more precise, the peoples of African origin that are being referred to belong to the African language families of the Nilo-Saharan, which includes examples such as the Dinka and Nuer of South Sudan; the Niger-Congo, far and away the largest sub-Saharan language family to include notable examples such as Yoruba (Nigeria), Swahili (eastern Africa), and Zulu (South Africa); and Khoisan, which includes the ethnic groups of Khoe and Sandawe in southwestern and eastern Africa. The other major African language parent family, Afro-Asiatic, while including groups north of the Sahara Desert and Asia, is meant here to only include sub-Saharan groups such as the Tuareg and the Afar and Amharic of Somalia and Ethiopia.

report points out, approximately 90 % of the world's engineers work for 10 % of the world's population, generally are the richest 10 % (UNESCO 2010). As we move deeper into the twenty-first century, the subject of engineering continues to be learned in a vacuum. Engineers study the technical and practical aspects of their professions, and at more progressive institutions engineering undergraduates are encouraged to study teamwork skills and communication. However, aside from these efforts, it is rare in the United States and in many countries to find an engineering graduate who is educated in the context, whether local or global, in which they might find themselves *doing* the engineering (Baillie 2006). This is often referred to as the sociotechnical context.

This article provides a brief overview of the literature of underrepresentation of African Americans in engineering, science, and science-related professions. The next section will assess some of the major arguments and debates that have dominated the literature. The concluding section will provide some practical and future directions for more research.

Literature Review

Brian L. Yoder, writing for the *American Society for Engineering Education* (ASEE), summarizes trends in engineering education in a 2012 article. Focusing on African Americans, the trends are less than sanguine. According to U.S. Census Data (2010), African Americans comprise 12.6 % of the U.S. population. In 2005, African Americans accounted for 5.3 % of the total engineering student population and for every year up to 2012, the percentage has dropped to 4.2 % (Yoder 2012). The trend for Hispanic Americans has been better, with figures of 5.8 and 8.5 % for 2005 and 2012, respectively. Finally, the largest ethnic minority demographic in minority engineering undergraduates is represented by Asian Americans, with figures of 14.1 % in 2005 and 12.2 % in 2012. The pinnacle of engineering achievement can be said to include induction into the prestigious National Academy of Engineering, which has a 1 % representation of African Americans, according to statistics from the *Journal of Blacks in Higher Education*.

Why the persistent underrepresentation? Many suggest that the causes start in K-12 education. For African American men, the statistics are particularly troubling. Of those who graduate, only 52 % of African American men graduate from high school in 4 years, and of that group, less than a fourth enter college. In contrast, incarceration rates for African American men are seven times that of white males (Matthews and Loftus 2014).[2] Even at well-established historically black colleges and universities (HBCUs) such as Morehouse College, an all-male institution, close to 45 % of Morehouse students will not finish in 6 years and the figure nationally approaches two-thirds (Matthews and Loftus 2014). The longer time for completion

[2] One of the most thorough explorations of this topic is Michelle Alexander's *The New Jim Crow: Mass Incarceration in an Age of Colorblindness* (New York: Perseus Press, 2012).

is normally attributed to financial and academic difficulties. A final challenge is that many of these students will opt to settle for less competitive colleges and universities, which can have significant impacts on their professional careers in engineering and STEM fields.

More specifically, from an academic point of view, many African American students arrive to undergraduate education with inadequate high school preparations (Matthews and Loftus 2014). Many of these students will play catch-up for a good portion of their undergraduate careers (Matthews and Loftus 2014). These challenges add time and cost to their education.

Another factor that is often noted as a major challenge to attract and educate African Americans in engineering and science is the profound lack of awareness of the past and present contributions of African Americans in engineering, such as the recent appointment of Norman Fortenberry as executive director of the American Society for Engineering Education (ASEE) in 2011. Many argue that the point to be made here is that many African Americans often cannot envision themselves as engineers and scientists. Some studies have tried to argue that African Americans are more apt to choose professions that have a social or social justice dimension to their careers and often, engineering and science are not seen as relevant to these issues. As Mario Azevedo notes, on the continent of Africa, what most Africans know about people of African ancestry in the United States and elsewhere in the Americas is that they were enslaved and that they continue to be discriminated against. There is a superficial knowledge of famous personalities such as Jesse Jackson, Michael Jackson, and Thurgood Marshall. When one turns to the accomplishments of African Americans in engineering and the sciences, there is almost no knowledge or awareness in these fields. The same appears to be true in the United States regarding the achievements of African Americans, especially in the hard sciences (Azevedo and Sammons 2005). The UNESCO report from 2012, cited earlier, makes a similar observation that engineering is routinely overlooked in many countries around the world and that engineering needs to become more human and humane to develop a wider appeal (UNESCO 2010). One logical place to rectify this lack of awareness could be to include the accomplishments of African Americans via instruction by faculty in African American studies. However, several challenges present themselves. One of them is that most fields require many years to evolve from areas of awareness to disciplines of practice. In many respects, African American Studies has yet to settle as a discipline. In the initial years of the development of African American Studies across the United States, as well as other ethnic studies efforts, much of the drive was a corrective drive against academic exclusion. The early pioneers thought that they could easily construct a reverse mirror image of the curricula they encountered. Few anticipated the difficulty of trying to (a) create a new discipline; (b) perform corrective functions; (c) become race relations generalists; (d) do Afro-*loco-parentis* duty; (e) work as minority ombudsmen, and (f) receive "precisely the same" treatment at tenure time as their colleagues not working in the field who most likely do not have these same sets of expectations on them (Adams 2005). The challenge here is to place yet another "corrective" function on faculty that is already tasked with responsibilities that other fields do not

require. While many faculty working in African American Studies may be more than willing to take on these awareness building efforts, the work of those in engineering education need to continue to encourage how to create "socio-technical" engineering and science undergraduates.

One of the major proponents to engage and develop a space to foster "sociotechnical" engineering *directly within* engineering education is the work of Caroline Baillie. Baillie, along with many others in engineering education, have devoted and explored topics to aid the practicing engineer in reflecting upon the nature and purpose within the engineering profession and how that is related to and implicated in social, economic and political issues (Baillie 2006). According to Erin Cech, engineers will incorporate considerations of social justice issues, as one topic, into their work only to the extent that they see such issues as relevant to the practice of their profession (Cech 2013). In an increasingly competitive and hostile environment in which engineers are forced to spend their lives fighting for higher profit margins, many engineers realize they are not engineering for those in need but for those who can pay. An academic literature has emerged to aid engineers and think about engineering education as a profession and to take appropriate action related to industrial development and globalization (Baillie 2006). One major aspect of the literature argues that two prominent ideologies within the culture of engineering—depoliticization and meritocracy—frame social justice issues in such a way that they seem irrelevant to engineering practice (Cech 2013). Depoliticization is the belief that engineering is a "technical" space where "social" or "political" issues such as inequality are tangential to engineers' work. Meritocracy, the belief that inequalities are the result of a properly-functioning social system that rewards the most talented and hard-working, legitimates social injustices and undermines the motivation to rectify such inequalities (Cech 2013). These aspects in the engineering education literature are linked to African Americans in the sense that as a group, social justice issues are a central aspect of the issues at stake in this community. These issues play themselves out in many areas, to include career choices and decision making processes for educational attainment. Engineering educations tends to be tangential to issues of social justice. Thus, an academic literature has emerged to explain the underrepresentation of African Americans in engineering professions.

The academic literature on African American underrepresentation is fledging and emergent. According to Lewis (2003), research in this area is important as it could inform policy and intervention efforts. However, due to the lack of more empirically based studies that is sometimes the case in the literature, intervention efforts tend to rely more on folk insight than on empirical evidence. Lewis argues that it is not uncommon for intervention programs to address factors that are not known to contribute to underrepresentation (Lewis 2003). He cites the case of intervention programs that present students with African American scientists as role models (e.g., Barisa and Holland 1993; Berrington and DeLacy 1993) or require African American students to take greater numbers of mathematics and science courses (e.g. Ellis 1993; Thomas 1984), in hopes that these measures will encourage greater numbers of African American students to consider pursuing science and science-related careers. Lewis asserts that there is no clear evidence that either

African American role models (Thomas 1984) or the number of mathematics and science courses that students take (Connell and Lewis 2003) causes or encourages students to pursue science and science-related careers.

The studies on underrepresentation of African Americans in science and engineering tend to cluster around five explanations: academic preparation, career interests, lack of educational and career planning, role models, and career opportunities (Hall and Post-Kammer 1987).

Academic Preparation

It is sometimes argued in the literature that poor preparation in mathematics and science is a pervasive problem for African American students leading to underrepresentation (Hall and Post-Kammer 1987). Proponents of this position point to data indicating that African American students enroll in fewer mathematics and science courses (e.g. Gilleylen 1993; Reyes and Stanic 1985), have low achievement scores in science, and have fewer experiences involving science (e.g. Kahle 1982; Thomas 1986). One rationale points to the inability of educational systems to enable African American students to find "science as useful out of school in the way that white students do….and that [African American] students have less awareness of how scientists work (Lewis 2003)." According to Cynthia Atman and others, African Americans and women often self-assess themselves as not being able to succeed in engineering and science professions (Besterfield-Sacre et al. 2001). Again, the explanation for this self-assessment is that African Americans point to poor performance in math and science courses in high school or if there was initial success in early math and science courses, when more advanced courses were attempted, poor performance deterred any more forward movement and persistence in these courses. A final important factor to note is that more African American families live below the poverty line than Hispanics or Asians, so they are likely to be in historically impoverished school districts that struggle to meet more diverse and intense student needs; since schools are funded in large part by state and local property taxes, the poor districts tend to have poorer schools and the rich, richer (Kozel 2012).

Career Interests

A second explanation that has been explored in the literature for the underrepresentation of African Americans in science and engineering is career interests. Some studies have been carried out to survey high school and college students. One pioneering study that surveyed college freshmen (Hager and Elton 1971) and one surveying high school juniors and seniors (Sewell and Martin 1976), showed that African American men express a greater interest in social service fields compared with White men, who prefer scientific and technical fields. The main rationale for

this trend argue that African American students gravitate towards careers with social orientations out of concern for the historical disadvantaged social position of African Americans (Hall and Post-Kammer 1987; Azevedo and Sammons 2005). Other studies have explored other explanations to account for career interests to include family socioeconomic status, cultural capital, group values, social capital and effects of significant others, and institutional factors (Simpson 2001).

Lack of Educational and Career Planning

A third set of arguments that appear in the literature points to a lack of educational and career planning. This argument is substantiated by studies indicating that African American students are unaware of various career opportunities such as engineering. Moreover, African Americans are more apt to seek career guidance from family members and peers who may not be knowledgeable about engineering careers (Lewis 2003).

Role Models

While there is literature that asserts that underrepresentation persists because there is a lack of African American role models in science and engineering positions, the research has not made a clear case showing that there is a link between role models and choices of careers among African Americans. The two main rationales to understand these arguments is that African American children will not aspire to careers in science and engineering if they do not see older African Americans functioning in these roles, and secondly, in the university setting, role models are necessary as gatekeepers and sources of moral support without which African Americans feel isolated (Lewis 2003).

Career Opportunities and Economic Incentives

The final thread in the academic literature points to income potential as a major factor in a students' career decision (Lewis 2003). Acknowledging that the income potential in science and engineering is high, it would seem that African Americans, like other students, would gravitate to these careers. However, Ogbu (1978) raised issues that attempt to explain why African Americans do not choose science and engineering as career options. One major issue is that African Americans have a belief that they have fewer job opportunities than Whites or other groups and that they perceive science and engineering careers as unattainable or off-limits to them.

Future Directions

The Pivotal Role of HBCUs

Many professionals in engineering education suggest several trends that can enhance and promote the success of African Americans in STEM professions. The first is the crucial role of HBCUs. One noteworthy study by Laura Perna et al. illustrates the role that Spelman College, one of the country's premier HBCUs, is playing in promoting the attainment of women in STEM fields (Perna et al. 2009). Concurrent with other studies, African American students who attend HBCUs as opposed to predominately white colleges and universities experience less social isolation, alienation, personal dissatisfaction, and overt racism (Perna et al. 2009) and that HBCUs seem to provide a social, cultural, and racial environment that is more supportive, caring, and nurturing for students and promotes academic achievement and success (Perna et al. 2009). Second, like other research (Bensimon 2007), the findings suggest the benefits of adopting a multi-faceted institutional approach that promotes students' academic and psychological readiness to pursue advanced degrees and careers in STEM fields. More specifically, Bensimon (2007) argues that the dominant paradigm around student success places responsibility for success on the student rather than on the institution. Bensimon argues that scholars and practitioners often "assume that institutional support systems are already in place and motivated students will take advantage of them" (Bensimon 2007). Bensimon urges one to not make this assumption. The faculty and administration at Spelman College do not seem to make these assumptions and take great ownership of their role in boosting student success.[3] The supportive, cooperative atmosphere at Spelman nurtures the academic achievement of women at Spelman. This finding can be extrapolated to African Americans as a whole, especially at HBCUs which have historically been institutions to promote the success of African Americans in higher education, even in a post-Civil Rights era. While acknowledging the decline of the percentage of African Americans attaining degrees from HBCUs, they continue to serve as a viable option for African Americans who want to pursue degrees after high school, especially in the STEM professions.[4] Finally, even with Spelman's clear commitment to promoting the attainment of STEM careers by African American women, financial challenges are a major impediment for many African American women.

[3] Another useful way to think about the philosophical differences of faculty at HBCUs and traditionally White colleges and universities is the distinction between pedagogy and andragogy. Among other characteristics, andragological approaches utilize a 'coaching' versus 'teaching' tone in instruction and engagement with students.

[4] In a recent ASEE study (2011), of the top 20 institutions that award engineering degrees to African Americans, ten are HBCUs to include North Carolina A&T State University, Howard, and Southern University, to name three notable examples.

Gaps in the Academic Literature on Underrepresentation

Bradford Lewis, writing in the *Journal of Women and Minorities in Science and Engineering*, points to several areas for more research: (1) generate more empirical research; (2) develop more precise meanings of the preponderance of factors found to correlate with students' career choices; (3) define more sharply some of the constructs used to explain teacher influences on students' career choices to pursue math and science; (4) nuance the research to not only assume that there are deficiencies in the life histories of African Americans as related to science and engineering, and (5) to sharpen the explanatory model for race.

The Need for African Universities to Move towards Research and Inclusion in the Policy-Making Process

In Africa, most institutions of higher learning have had to historically focus on teaching and educating their populations as the waves of independence began to sweep across the continent in the 1950s (Atuahene 2011). With the arrival of military coups and the "lost decade" of the 1980s in much of the global south, African intellectuals had to make decisions to pursue academic careers elsewhere, most notably Europe and the United States.

According to a major report from the United States Educational, Scientific and Cultural Organization (UNESCO), published in 2010, data shows that developed, industrialized countries have between 20 and 50 scientists and engineers per 10,000 population, compared to around five scientists and engineers on average for developing countries, and down to one or less for some poorer African countries (UNESCO 2010). Recent data suggests that Africa only accounts for 8 % of research and development expenditure and 1.4 % in publications in engineering and the sciences.[5] This trend continues and is also noted in the most recent UNESCO 2010 report.

According to Felix Atume, a major issue facing the growth of the engineering profession in many sub-Saharan African countries is the lack of involvement of engineers in policy matters as many political leaders seldom take into consideration the key role that engineers and engineering can play in development (Atume 2010).

Finally, African countries should consider developing stronger south-to-south partnerships to mitigate against partnerships that are with the global North driving the research agenda. These partnerships could foster more dialogue and synergy amongst developing countries to make decisions on how to apply and utilize emerging technologies, such as nanotechnology to provide clean drinking water.

[5] As a point of comparison, Asia accounts for 21.1 % in publications and 30.5 % in R&D expenditure. Please see the *UNESCO Bulletin on Science and Technology Statistics*, Issue No. 2, September 2005.

Conclusion

As a final note, Caroline Baillie provides an example of the socio-political context constraints that the Basuto people face given the issues of globalization and the challenges of increasing the numbers of people who have been historically underrepresented in engineering and science:

> Who benefits and who pays? Who needs what and when? How will the project survive after the planners have gone? Who contributed to its planning and execution? Who decided what was needed? Who paid for it and why? What do they stand to gain? Are proceeds distributed equitably? Does it provide fair compensation for those affected? Are people treated ethically and justly both within and as a result of the project—workers, those affected but not involved and those who are 'users'? Who gets the jobs? Who makes decisions about pay and conditions? Do workers have to relocate? What effect does this have on their lives, their family's lives and those of their community? Is the engineering project contributing in any way to the increasing gap between the rich and the poor? How do you know? How do you find out? Do you feel you are in a position to do the right thing in your current job? (Baillie 2006)

As with any well-designed engineering project, a lot of questions are asked. More questions—such as the some of the neglected ones Baillie is raising—and research needs to be done to promote the future success of African Americans and other underrepresented groups in engineering.

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