Addressing Negative Racial and Gendered Experiences That Discourage Academic Careers in Engineering


Engineering faculty members play a multifaceted role in the profession in that they help discover, promote, and disseminate advancements in technology. However, many potential faculty members are dissuaded from entering academia. Graduate mentoring programs need programmatic innovation to address racial, gender, and other identity-based biases in engineering and academia.

Forces such as rapid changes in technology, changing racial and ethnic demographics, national security, and globalization have all fueled the push to increase and diversify the science and engineering workforce. To succeed in this endeavor, however, universities must attract and retain a diverse pool of scholars in the science and engineering disciplines. The creation of even a small group of successful Black PhD engineering faculty, who can form a network and win tenure at key institutions, can create an intellectual and technological movement with broad, sustainable influence. For example, a single PhD educator from an engineering department can teach hundreds of students for 30 years or more, and his or her students could train hundreds more. In addition, research published by a single PhD educator can shape the understanding of many future engineering experts and professionals. The presence or absence of Black engineering faculty can affect the recruitment, training, and success of students of color for generations.

While the number of engineering faculty is rising, gaps in ethnicity and gender persist. According to data from 2013, 48 percent of engineering schools had no Black tenured or tenure-track faculty members,
19 percent had only one, and 12 percent had exactly two (www.asee.org/datamining). The remaining 21 percent had more than two Black tenured or tenure-track faculty members, but many of those schools are historically Black colleges and universities. Although the number of female tenured and tenure-track faculty members has gradually increased, as of 2013 only 12.5 percent of all US engineering institutions with at least 25 tenured or tenure-track faculty members have more than 20 percent female faculty members.

This article describes an investigation into the critical factors that leave Black people as one of the most underrepresented racial groups in engineering faculty positions, despite intervention programs that aim to broaden the participation of minorities in engineering. We obtained data from interviews and focus groups of the 70 Black engineering PhD students and postdoctoral scholars who participated in the study. Our research also examined the mentoring programs in engineering by interviewing minority engineering program directors for their perspective on the challenges facing Black engineering PhD students and postdoctoral scholars. Despite some programs that have succeeded in mentoring Black engineering PhD students and postdoctoral scholars, all the mentoring programs haven't substantially improved the progress of Black people among the engineering faculty ranks. The racial and gendered experiences of Black engineering PhD students and postdoctoral scholars have significantly impaired their career pathways. Although we use the term Black in this study to describe US-born Black students and foreign-born Black students, we’re aware of the nuanced racial identities of each student as a result of their nationalities and cultures. Parts of this work have been presented at other venues. Key findings from the work are as follows:

- Many participants had negative perceptions of what it means to be an engineering faculty member.
- Participants both observed and experienced racial and gender marginalization.
- Many participants recalled the feeling of being an impostor in the academic environment.

This article extends prior work through the design of a holistic mentoring program that prepares Black engineering PhD students and postdoctoral scholars for a career in the professoriate. In addition to engineering perspectives, scholarly contributions from fields such as sociology, psychology, and education add components to the mentoring curriculum that broaden the representation of Black people among engineering faculty.

Understanding the Barriers to Broader Participation

Expanding the racial and gender representation of engineering faculty has become a top priority in many engineering colleges and departments across the country. Despite the best intentions, though, many organizations have failed to reflect societal demographics within their faculty ranks. Techniques and strategies exist to recruit candidates from traditionally underrepresented groups, yet the full participation of these groups hasn't been achieved.

This section discusses both micro-aggressions and the impostor phenomenon, and their impact on the successful development of potential faculty members from underrepresented minority groups. In addition, the culture of graduate education can also impede the progress of these groups.

Recruiting and Retaining Black Engineering Faculty

The following issues impact Black engineering faculty recruitment and retention: a lack of critical mass of engineering faculty of color, PhD candidates’ having trouble envisioning themselves as faculty, unwelcoming institutional climates, institutional and social barriers in the academy, racial/ethnic stereotyping, a lack of role models or mentors with whom to identify, and the “revolving door” syndrome of minority faculty (that is, faculty turnover). Unfortunately, there are biases along gender, racial, and other identity-related lines in the engineering profession at large as well as within academic settings. Female engineers have had their competence and career commitment questioned, and Black women have faced discrimination resulting from both race and gender biases.

Even though some Black engineering PhD graduates would prefer to serve on the faculty at institutions where they can remain close to supportive networks or where there is a sizable Black community nearby, not every scholar can obtain a professorship in such locations. These scholars must be prepared for careers in regions of the country and at institutions where some aspects of their racial or gender identity could be deemed problematic. Institutions also bear responsibility to offer nonhostile working environments. The intersectional nature of social identities among PhD students and postdoctoral scholars can
dampen their interest in pursuing faculty positions in departments where discrimination prevails, whether through readily observable, overt actions or through more covert micro-aggressions that are representative of the current racial landscape.

Racial and Gender Micro-Aggressions
Chester Pierce proposed the term racial micro-aggressions to explain a subtle but persistent form of racism that greatly affects the lives and experiences of Black people and other people of color.7 Pierce and his research team defined racial micro-aggressions as "subtle, stunning, often automatic, and non-verbal exchanges which are 'put downs' of blacks by offenders."8 As Pierce argued, racism has transformed over time from overt and blatant forms of discrimination and prejudice to more covert, indirect, restrained, and ambiguous demonstrations. Pierce reminds us to look not for the gross and obvious but the subtle snubs, dismissive looks, ignorant gestures, and insulting tones; these everyday exchanges convey denigrating messages while appearing unintentional and unconscious.

Micro-aggressions, based on race, class, and other forms of oppression, can appear in a variety of contexts, such as being intentionally picked last in a lab group because you’re Black or female.9 Micro-aggressions, both within and beyond the classroom, can leave students feeling both invisible and hypervisible, as their experiences are omitted, distorted, and stereotyped.10 Thus, the cumulative effects of micro-aggressions contribute to self-doubt, frustration, and isolation. Racial micro-aggressions have only been addressed by educational researchers recently, in part due to the everyday and routine manner in which they appear.

Impostor Phenomenon
Originally researched among White, middle- and upper-middle-class, high-achieving women,11 the impostor phenomenon describes a person’s belief in and experience of her- or himself as an intellectual fraud. These individuals find it difficult to internalize their achievements and are reluctant to ascribe their successes to intrinsic skill or intelligence. Despite external evidence to the contrary, they tend to attribute their successes to fleeting causes (such as happenstance or error). Those with impostor feelings often live in fear of being exposed as a fraud and consequently hold themselves to exceptionally high standards.

The impostor phenomenon has been tied to clinically significant mental health symptoms of depression, generalized anxiety, and low self-esteem.12 Very few published studies have examined the relevance of this construct to ethnic minorities. In one example, Kevin Cokley and colleagues examined differences in minority status stress, impostor feelings, and mental health in a sample of 240 ethnic minority college students.13 Results showed that African Americans reported higher minority-status stress than Asian Americans and Latino and Latina Americans, whereas Asian Americans reported higher impostor feelings. In their study,13 the authors examined minority-status stress and impostor feelings as predictors of mental health, where impostor feelings were stronger predictors of mental health than the stress of having a minority status.

Institutional Culture and Climate
Other barriers that Black engineering doctoral students experience pertain to the structure and climate of graduate school itself. A growing body of research indicates that academic and social integration might be even more influential than academic abilities for the retention of doctoral students in their graduate programs.14,15 The proverbial “sink or swim” atmosphere of doctoral education, in which individuals are challenged to overcome difficulties independently, favors the structural advantage and privilege of whiteness, which can lead to feelings of isolation and self-doubt for many Black students. Some mentoring relationships also follow a “heroic journey” model, where the mentor (research advisor) challenges the mentee (graduate student) to struggle independently instead of providing support and guidance.16 The limited interactions that Black people have within engineering faculty social networks, including exchanges with their advisors and other faculty, lead to a decrease in opportunities for them to collaborate with others, to expand their research, and to publish their findings.17
Research Study
Given these challenges, we investigated the technical, societal, and cultural influences that influence the career decision-making process leading to the professoriate. Our study was framed by the following key questions:

- What are the critical factors in the academic and career decision-making of Black engineering PhD students and postdoctoral scholars?
- What (if any) effects do racial micro-aggressions and other forms of racial and gender bias have on the career decision-making of Black engineering PhD students and postdoctoral scholars?

In this section, we describe how we recruited participants for our study. We also discuss the methods we used to collect data from the participants and how these data were analyzed. The major findings of our study have been organized under racialized experiences and gendered experiences of the participants.

Study Participants
Our study includes 70 participants who are Black engineering PhD students and postdoctoral scholars (Table 1). Although we interviewed participants from a variety of engineering disciplines, the most frequently cited major areas and departments of participants were industrial and systems engineering, information science, biomedical engineering, material science and engineering, chemical/biomolecular/biological engineering, civil/environmental engineering, mechanical/aerospace engineering, computer/information science engineering, and computer and electrical engineering. Participants were affiliated with diverse types of institutions: predominantly White institutions, historically Black colleges and universities, private universities, public universities, and technological institutes.

Most participants were affiliated with institutions in regions covered by the Eastern and Central Time Zones. Institutions were selected for participant recruiting because of preexisting professional connections that the authors had with key faculty and staff or the presence of at least 10 Black engineering tenured and tenure-track faculty members, according to 2012 data. Participants were also recruited at national engineering-related conferences. They were invited to participate in the study via

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*Individual school names have been replaced by descriptive categories. Numbers are used to represent instances of each descriptive category.
An overwhelming majority of the Black engineering doctoral students we studied felt they had to expend extra energy to prove themselves to their advisors, professors, peers, and even mentors by going above and beyond the stated requirements of assignments.

Email, primarily through requests sent from key staff at institutions and conferences.

**Data Collection and Analysis**

Participants were interviewed at their universities, a national engineering-related conference, or over the phone. Following the guidelines for conducting case study research, the interview and focus group formats were semistructured and guided by a clear list of issues to be addressed and questions to be answered. Within this format, interviews were conducted with a degree of flexibility, thus allowing participants to develop ideas and help shape the order of topics covered. All the individual and focus group interviews were audio-recorded. Participants who attended an in-person interview were also video-recorded with their permission. We incentivized participation in the study by offering a stipend in the amount of US$35 to each participant.

Interviews lasted from 45 minutes to just over 2.5 hours and were professionally transcribed. For focus groups, researchers’ field notes were utilized to aid in the transcription process and speaker identification. After transcription, the interviews were analyzed using the themes embedded in the structure of interview protocols as well as an iterative coding scheme. For the iterative coding scheme, multiple researchers analyzed initial transcripts and identified themes individually, compared their results, and then came to a consensus on a final coding scheme that was then used to code the remaining transcripts.

We relied on two methods of textual analysis: computer-aided (nVivo) and manual. A phenomenological approach helped with contextual analysis of the semistructured interviews, focusing on the students’ experiences and interpretations of their experiences in their doctoral programs. Phenomenology, which is rooted in philosophy, enabled the research team to develop an understanding of these participants’ “reality,” whatever they perceived that to be. In essence, this approach involved investigating individual or group perception of reality as those individuals and groups construct it. Transcriptions were analyzed with an eye to participants’ responses as they related to the themes and codes that emanated from the research questions. For example, the code category *Engineering as Racialized Experiences* directly relates to the research question investigating students’ interpretations of their engineering experiences in ways that were either racially affirming or racially oppressive. The category and codes under *Future Career Perspectives* emphasize participants’ future selves and the challenges and opportunities they anticipate facing in those careers. The team developed 12 index codes and 52 subcodes for all interviews. The interviews were then recoded using the agreed-upon coding architecture.

In performing the study, it was important for researchers to juxtapose their own academic and research backgrounds with their positions as educators of Black doctoral engineering students, former engineers, and fellow doctoral students. Studying and writing about these participants warrants acknowledgment and discussion of our collective positionality and subjectivity. The overall research project, as well as this particular study, was influenced by our research interests (that is, marginalized students’ experiences with obstacles in engineering education) and by our various experiences as they related to those of our participants. Because most of our team members are Black, and nearly all have either obtained or are pursuing doctoral degrees, we discovered that the doctoral students’ experiences were very familiar. Although we recognize that there might be some shared experience, we remain mindful of nuances in experiences that shaped the motivations of the study participants.

**Participants’ Racialized Experiences**

An overwhelming majority of the Black engineering doctoral students we studied felt they had to expend extra energy to prove themselves to their advisors, professors, peers, and even mentors by going above and beyond the stated requirements of assignments. Professors and advisors often delivered communications and suggestions that the participants needed to do so, which was simply a proxy for the perceived necessity of performing work better than White and Asian PhD students. Black engineering doctoral students formulated this perception from a number of
experiences. Some said their advisors or mentors had seldom worked with non-Asian or non-White students and suggested that the Black students should adopt the same work ethic as those students to be successful in the program. Some students’ racialized experiences took the form of professors questioning, second-guessing, or otherwise treating them with less respect than they did majority students. Most students also reported a lack of guidance about career opportunities in the professoriate.

Advisors, mentors, and professors accounted for some of the negative racialized experiences that evoked feelings of needing to go above and beyond, but most students also reported a preponderance of racialized experiences with their peers. Some Black engineering doctoral students said that before they even started their programs, other students assumed that they wouldn’t do well. These negative experiences persisted into the programs, such that Black students felt their majority peers would question how and why the Black students were accepted into the program; ignore, overlook, or exclude Black students when they tried to collaborate with peer groups; openly and frequently question or cast doubt on Black students’ answers or contributions in classroom and lab settings; and indicate that Black students would by default serve as the representative for all things Black (and poor).

Although experiences with advisors, mentors, professors, and peers all contributed to the participants’ determination to go above and beyond expectations, these experiences came in two distinct forms: overt actions and micro-aggressions. Many students said their experiences occurred during informal conversations and interactions, but they also spoke of experiences with overt, racialized marginalization. These overt experiences sometimes took the form of being excluded from group work. In addition, participants reported overhearing Asian students talking among themselves in their primary languages in such a way as to suggest that the conversation was about the Black students.

In some ways, the overt, racialized experiences were easier for students to process than the micro-aggressions. Due to the subtle, everyday manner in which these aggressions occurred, students often had difficulty recognizing and processing their experiences. Often, some length of time after an incident occurred, students had to ask of themselves or family and friends, “Wait, was that racist?” Other students had the perception that their race wasn’t salient in their graduate school experience, which led to self-doubt, as in this example from Neil, an environmental engineering student at a large southern university: “The only threat was probably posed by me in this space.” (The names of the participants and their universities are pseudonyms. Names have been changed to ensure confidentiality.) However, the students who felt that their experiences were not racialized weren’t the only ones who felt self-doubt.

More than half the students in the study said they consistently experienced feelings of being an impostor but suggested the feelings were created partly by their own motivation to achieve and their sense of not belonging to a community of practice. While students suggested that their feelings of self-doubt and of being an impostor were created by their own motivations to achieve, it’s difficult to ignore how the racialized experiences they described in other portions of their interviews might be connected to their feelings of not belonging in the elite space that is a doctoral engineering program or the professoriate.

Remarkably, as students recounted their racialized experiences in focus group settings, many participants realized that their Black peers shared their feelings of marginalization. This observation led some to conclude that there must be structural and institutional barriers that help to foster the impostor phenomenon. Consequently, some students who initially said their racial identity wasn’t salient in their graduate school experience later postulated that some of their doubt might be linked to structural and institutional racialized barriers. Some students discussed going to mental health counseling services and experiencing physical health complications, such as ulcers, panic attacks, and sleep fatigue, as a result of these experiences.

Participants’ Gendered Experiences
Black female engineering students described the “female engineering experience,” which exhibits these characteristics: low numbers or a complete absence of female engineering faculty (there were no more than two full-time, tenured/tenure-track Black female engineering faculty at any of the universities at which interviews were conducted, and usually there were none); gendered micro-aggressions (“Are you planning to get pregnant any time soon?” or “Don’t take classes from the chicks in this department.”); the male huddle (males collaborating together at the exclusion of females); an assertive female is viewed as bossy, whereas a man is viewed as taking command of the research; the catch-22 (if viewed as too hardworking, then she’s seen as a threat, but if not hardworking enough, she’s seen as too soft); as well as demeaning jokes and hostile, unsupportive environments.
Some Black female students accused their male advisors of being sexist, racist, and demeaning. They perceived their male advisors and teachers as frequently challenging of their competence or intelligence. Male professors openly chastised them for minor issues, even to the point of verbal abuse. Black female student participants also said that they were less likely to be listened to and more likely to be questioned about their research designs. Many of the Black female participants concluded that repeatedly proving themselves within their male-dominated fields was a necessary evil while working toward their engineering degrees. They felt that a man's past achievements were perceived as substantiating his current competence and future potential, but their own past achievements were seen as flukes or attributed to the work of others.

Most female student participants felt they were just as well prepared as males (or even better prepared) to pursue engineering doctoral degrees and that they took their studies more seriously. Some of the Black male student participants agreed that majority-female study groups were particularly helpful in supporting their academic success. Black female student participants with female advisors described compounded benefits associated with the familiarity of the “female engineering experience.” The female participants appreciated female advisors or close faculty members simply because they “get it”: they understand what it’s like to be the only one in the room, having to prove to the men that they’re intellectually deserving of a space at the table. They further described the encouragement they receive from their female professors as optimistic and supportive, that they pushed them to excel at unprecedented levels to counter lowered expectations. Familiarity with sexist encounters were also discussed in relationships between female advisors and advisees, and that despite the sometimes 20-year age gap, the experiences remained virtually unchanged (the departmental mentality that women can’t achieve certain engineering-related goals or the stereotype that women aren’t as smart as their male counterparts).

Despite the benefits that some experienced with female advisors, female engineering participants also spoke of their fears of becoming a faculty member. These fears were fueled, in part, by accounts of Black females or other female engineering faculty being denied tenure or leaving under the threat of being denied tenure, coupled with the steady and unchallenged stream of male professors being hired into their engineering departments. One Black female participant stated, “Sometimes they just look at me like I’m stupid,” which, for her, has served as a deterrent against pursuing a faculty position. They also discussed the problems with the competitive culture of their engineering departments that has hindered men and women from becoming allies.

Most of the Black male students in this study speculated that their engineering academic pursuits would be more difficult if they were Black women. Black male students said they were more likely to be perceived as smart in engineering because they’re male. They also said that through other male-dominated activities, like sports, Black male students discover greater commonality with some non-Black male students. Black males also recounted witnessing sexist practices, such as their female colleagues often being the last picked for group projects and almost never being asked to participate in study groups.

**Intervention through Mentoring**

Our research has shown that Black engineering faculty who can successfully advance to the ranks of full professor or are poised to do so all share one beneficial characteristic: a strong network of faculty mentors who nurture their professional career development. Moreover, their mentoring network included other Black mentors, either within or outside their discipline, with whom they could discuss the challenges they face uniquely as Black engineering faculty members. These mentors served as advocates for their advancement in academia; they also helped facilitate opportunities with White allies and advocates. These mentors have expanded their reach by presenting content at development workshops for academic careers.

**Benefits of Mentoring**

The implementation of mentoring networks is one approach that fosters more equal opportunity in engineering, addresses the cumulative disadvantages faced by Black PhD graduates, and creates an environment that’s more positive for Black people. According to Lisa Tsui, working groups investigating the obstacles to the advancement of Black people in science, technology, engineering, and mathematics (STEM) have identified mentorship as the most important factor contributing to the success of Black graduates. Through the use of mentors and mentoring programs, other recommendations can also be incorporated for improving conditions for Black people in engineering, including making available general encouragement, drawing attention to stereotypes and misconceptions in the field, providing Black role models, and helping Black people to be more involved in the
professional and departmental community. Mentoring networks also disseminate information about problems that Black people face in engineering fields, thus helping students realize the extent of the overarching issue, recognize that they aren’t alone, and receive solutions and coping strategies for when challenges arise.22 Finally, having a mentor positively correlates with success in an individual’s career.16 Mentoring and collaboration are important factors in both self-perception of academic capabilities and graduate publication success.23

**Academic Development Workshops**

While graduate minority mentoring programs that focus on presentation skills, networking, and other professional development areas are invaluable, there’s a need for programmatic innovation that emphasizes a holistic approach and addresses racial, gender, and other identity-based biases in engineering and academia. Our findings illustrate the utility of a minority graduate mentoring program to empower potential Black engineering faculty to negotiate the reality of bias within the profession. After reviewing topics from a series of workshops, we identified a lack of topics addressing race and gender within the professoriate (see Table 2).

**A Race- and Gender-Conscious Mentoring Program**

The design of a holistic and innovative mentoring program that adequately addresses race, gender, and other types of biases requires the input of multiple perspectives. In addition to engineering perspectives, scholarly contributions from fields such as sociology, psychology, and education provide a greater positive impact for Black PhD students and postdoctoral scholars. The aim was to create a video-based mentoring series to be used as standalone instruction or in conjunction with in-person mentoring workshops that include Black PhD students and postdoctoral scholars.

Faculty scholars were selected and invited to Vanderbilt University for a 2.5-day retreat to develop the content for the mentoring program. The expertise of these scholars focused on crucial areas, including race, culture, and social stratification; social justice in education; the affirmative personal and academic development of Black men and boys; mathematical and racial identity; racial socialization processes; and race and gender intersectionalities. The faculty retreat included the following participants (in alphabetical order):

- Tony Brown, associate professor and associate chair of sociology, Vanderbilt University;
- Dorinda J. Carter Andrews, associate professor, Department of Teacher Education, Michigan State University;
- Robbin Chapman, associate provost and academic director of diversity and inclusion, lecturer, Department of Education, Wellesley College;
- Monica Cox, associate professor, School of Engineering Education, Purdue University;
- Derek Griffith, associate professor, Center for Medicine, Health, and Society, Vanderbilt University;
- Bryant Marks, associate professor of psychology, Morehouse College;

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*MFDW: minority faculty development workshops
• Danny Martin, professor and department chair of curriculum and instruction, University of Illinois at Chicago;
• Susana Morris, associate professor, Department of English, Auburn University;
• Jomo Mutegi, associate professor of science education, School of Education, Indiana University-Purdue University Indianapolis (IUPUI); and
• David Stovall, associate professor of African-American studies and educational policy studies, University of Illinois at Chicago.

The scholars were asked to review the research findings before the retreat to develop two presentations that would be professionally video-recorded. During the retreat, each scholar rehearsed his or her presentation and received feedback from the other scholars in preparation for the final video-recording. The two presentations served the following purposes:

• A report-specific video presentation directly addressed the related findings. Each scholar lectured on a salient theme that arose from the research findings and applied his or her own expertise to address the theme.
• A general video presentation presented personal experience in academia. Some of the questions addressed were these: What was it like during your first year as a faculty member? Were you positioned as the “diversity” faculty member, and if so, how did you negotiate this designation? If you could speak to your early-career self, what advice, encouragement, or warnings would you give?

The scholars developed provocative and insightful video mentoring presentations. The recorded videos facilitate dissemination through a Web portal (http://blackengineeringphd.org) as a webinar series, as well as through presentations at previously established mentoring conferences. The website has been disseminated through the same channels used to recruit participants for the study. The video mentoring series has been informed by understanding of the social construction of race, the impact of discrimination on mental health and wellness, and the experience of becoming a faculty member as a means of transformational change. Scholars from sociology, psychology, and education have analyzed this study’s findings to produce strategies to inform and potentially recruit Black engineering doctoral students to pursue faculty positions.

Acknowledgments
We thank all the Black engineering PhD students and postdoctoral scholars who participated in this study. We also thank the staff at the American Society for Engineering Education for granting access to demographic data. We thank the National Association of Multicultural Engineering Program Advocates and the Association for Computing Machinery Richard Tapia Celebration of Diversity in Computing for allowing us to collect research data during their conferences. Finally, we thank the faculty who participated in a scholars’ retreat to discuss the findings of this investigation. This material is based on work supported by the National Science Foundation under grant numbers EEC-1361025 and EEC-1444908.

References


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