Engineering a Brighter Future: Increasing the Representation of Women of Color in Engineering

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Abstract

The engineering field is predominantly composed of white males, with little representation of women or people of color. Women of color are represented even less in the engineering field due to their intersectional identities combining both gender and race. Overall, minority women do not conform to the traditional engineering student or the ideal worker norm, causing challenges for these engineers. The structure of engineering education prevents women of color from receiving the same opportunities as men, women, and men of color because of social pain, stereotypes, and discrimination. Also, the engineering workplace is not welcoming to women of color because of social isolation, implicit bias, and institutional housekeeping. This project will take a closer look at the existing research as well as perform some research of its own through interviews and journal investigations. This project will suggest practical ways for university heads and workplace managers to allow and encourage women of color to pursue a career in engineering. This will include social support networks, diversity workshops, implicit bias training, and equal workload distribution. Using these suggestions, women of color will face fewer challenges and have more representation in both engineering education and engineering careers. Engineering culture will be transformed to involve and welcome diversity and inclusion of women of color.

Keywords: women of color, engineering, education, workplace, representation

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She was a young black girl who loved math and science. She was told she would never make it in a field dominated by white males, but she refused to listen and attended college in pursuit of an engineering degree. During her time in college, she was typically both the only female and person of color in her classes. She felt unwelcome and uncomfortable even though she was following her own dream. One of her professors even questioned her career choice due to the color of her skin and her gender. Despite the many obstacles she faced, she received a bachelor's degree in industrial engineering from the University of Tennessee and a master's degree in industrial engineering from North Carolina Agricultural and Technical State University. However, the challenges did not end there; when she entered the workplace, the oppression simply continued. As the only female of color in the engineering workplace, she received many confused, shocked, and even disapproving looks simply because she was a black woman with an engineering career. Some white male coworkers would make racist or sexist jokes and remarks about her, causing her to feel out of place at her own job. Even though she had to overcome discrimination, she persevered to become an esteemed engineer, specifically a project manager at Eastman Chemical Company in Kingsport, Tennessee. This is the story of Tanya Foreman, whom I had the pleasure of meeting at a Women in Engineering event hosted by Milligan College in Fall 2018 (2020).

Mrs. Foreman was able to persevere through these challenges as she studied to become an engineer, but not all women of color do. According to a study by the Society of Women Engineers and the National Society of Black Engineers, women of color account for fewer than four percent of bachelor's degrees awarded in engineering (Rincon & Yates, 2018, p. 5). Like

Mrs. Foreman, many young girls are discouraged against becoming an engineer simply because it is traditionally a field populated by white men. At universities, women of color in engineering classes often feel out of place or unwelcome due to the typical demographic of engineering majors. This stigma results in many of these women of color switching to more welcoming programs and majors. Minority females are extremely underrepresented in the engineering workplace as well, making up less than two percent of engineering professionals (Rincon & Yates, 2018, p. 5). Since they are not the traditional white male engineer, women of color simply do not have the same opportunities to pursue engineering as white males, white females, and minority males. The terms women of color or minority females refer to biological females who are not white, including African Americans, Hispanics, Latinos, Asian Americans, American Indians, Native Alaskans, Pacific Islanders, and multiracial women (Tate & Linn, 2005, p. 7; Wu & Jing, 2011, p. 82). Engineering colleges and workplaces need to give women of color more opportunities by creating a more welcoming learning environment and workplace, thereby transforming engineering culture itself.

Women of color are not the traditional picture of an engineering student or professional engineer. Women have priorities in life other than their engineering job, so they do not conform to "the ideal worker norm, a prevalent gendered standard within STEM of pure dedication to scientific work" (Kachchaf et al., 2015, p. 175). Since engineering has been populated by white men for so long, it is out of the ordinary for a woman of color to pursue an engineering career, resulting in many challenges (Frehill & Ivie, 2013, p. 17). For example, Yvette, a professor of engineering at a private research university, experienced many roadblocks in her career in the engineering field. Her chair always assumed that she was not working hard enough, likely because of the stereotype that people of color do not work as hard as white people. Also, she hid

her pregnancy for as long as possible because she would lose credibility as an engineer. Yvette returned to work only a week after giving birth, yet her boss and colleagues questioned her work ethic. Because white men are able to devote all their time and effort to the job, Yvette's coworkers were shocked that her life involved more than just engineering. She pursued tenure at this university, but "the dean…denied her tenure at some point in the process without informing her" (Kachchaf et al., 2015, p. 187). Female minorities' struggles in engineering stem from not fitting the traditional view of an engineering student or professional engineer. By addressing each challenge, the culture of engineering will transform to encourage more diversity in the field.

Minority female engineers often lack confidence in themselves due to the scarcity of role models and their lack of support. So few women of color are in the engineering field that young girls have no one to admire while pursuing engineering. These minority female engineers often receive less recognition due to stereotyping and bias, so they are not as well known and represented in engineering, contributing to the lack of female role models of color. When these girls are in engineering school, they do not have the story of a minority female engineer to "demonstrate that success is possible for individuals who look similar to them" (Rincon & Yates, 2018, p. 5). Because of this, they lack the self-confidence that they need to thrive in engineering school (Tate & Linn, 2005, p. 484). Furthermore, women of color in both engineering education and the engineering workplace lack the support they need from their peers and colleagues. If they do have friends and mentors in their classes and workplaces, these friends are likely not experiencing the same challenges because they are likely not both a woman and a minority. Women of color need the support of fellow women of color in order to succeed in their classes or career, but they rarely receive support in this way. Also, some of their colleagues and peers may undermine them because of their traditional views of the engineering field (Ong et al., 2020, p.

596). Self-confidence is a big factor for success in engineering, yet many women of color lack it because of the dearth of support and relatable role models.

In addition to self-doubt, female minorities in engineering often feel socially isolated from their peers and coworkers. Women of color are typically the only female or minority in their class or workplace. Josephine, an African American engineer, said, "I was in research for 12 years and in those 12 years there was no other Black woman research staff member" (Ballenger et al., 2017, p. 168). Being alone in this experience, women of color commonly feel socially separated based on their gender and race (Rincon & Yates, 2018, p. 11-12). For example, Lisa, a black engineer, felt excluded in her workplace because some of her male coworkers went on a fishing trip, but she was not invited due to her gender (Ballenger et al., 2017, p. 171). Even though these men were respecting her identity as a woman, she still felt isolated at her job because she was unlike her coworkers. This feeling of loneliness is a common theme for minority females pursuing professional engineering. Many minority female students do not feel welcome at their universities because of their race and gender. Monica, a black engineering student, did not feel welcomed by her professors because her white peers all personally connected with each professor, yet no professor ever reached out to her (Ballenger et al., 2017, p. 165). Also, these students struggle to relate to their classmates because they have different life experiences involving race and gender (Ong et al., 2020, p. 600). Women of color in engineering experience social pain because they feel excluded in their studies or their workplace.

To combat these social challenges, social support networks could be implemented in both engineering education and the workplace. These groups would bring together women of color across different academic years and workplace departments to bond through shared experiences.

Social groups for minority female engineers would provide opportunities for networking as well as support, boosting their confidence (Rincon & Yates, 2018, p. 16). In addition to specific demographical events, universities and workplaces could host non-gendered social events to boost confidence and promote intercultural relationships. Also, they could join professional organizations such as the STEM Women of Color Conclave or the Minority Women in Science Network. These societies give female minorities "opportunities for networking, mentoring, collaboration, and cooperating on advocacy efforts" (Liu et al., 2019, p. 34). By participating in these organizations, women of color will have more opportunities for success in engineering. Families and friends are also a powerful support network for women of color engineers, so university engineering programs and workplaces should strive for a familial closeness to allow for more support. This intimacy can be achieved through periodical bonding experiences such as trips, dinners, or fun events (Ong et al., 2020, p. 599). These methods of supporting minority female engineers will counter the social isolation, self-doubt, and loneliness that they often feel in the education system and the workplace.

Like social support networks, mentorship programs would greatly benefit women of color in the engineering field as they encounter social adversity. Because many women of color engineers lack confidence, these mentors would provide inspiration for them in their studies and careers. For the most benefit, the mentor should be a minority female engineer so that the mentee can better relate to the mentor (Kachchaf et al., 2015, p. 181). In educational settings, the mentor could be an upperclassman student, a graduate student, a professor, or even a local engineer. In the workplace, the mentor could be an engineer of a higher rank than the mentee. In both instances, the mentor introduces the less experienced student or engineer to the culture of engineering and supports their studies and research. The mentor would "guide them and share

their experiences with them" (Tate & Linn, 2005, p. 489). Women of color in engineering simply

want to be understood, and this mentorship, provided that the mentor is also a woman of color,

would fulfill this need. This camaraderie would combat self-doubt and social isolation because

the mentor and the mentee would bond through shared personal experiences (Liu et al., 2019, p.

35). However, since few women of color pursue engineering, it might be difficult to find mentors

who are women of color engineers. To adjust to the situation, women of color from different

departments could become mentors for minority female engineers. They would not share the

same experiences in engineering, but they would share common experiences as females of color.

These women of color engineers would finally feel included in something related to engineering,

and they now would have a role model who is their same race and gender to admire. Mentorships

for women of color in engineering education and careers will counter the social pain that they

experience when pursuing an engineering career.

      Oftentimes, women of color experience discrimination and harassment in their

engineering studies and careers due to their race and gender. Most of the time, the racism and

sexism are subtle, which leads to more mental contemplation that can actually be more mentally

and emotionally harmful (Liu et al., 2019, p. 34). When women of color experience subtle

discrimination, they question whether or not they are reading into the situation, which takes

emotional effort and stress. They spend time in mental rumination, wondering if the perpetrator

meant to harm them in a subtle way. In more extreme cases, the harassment is obvious and blunt.

Jasmine, an African American engineer, experienced discrimination when a white male

subordinate bitterly commented, "You're a nigger woman and that's why you work here and you

gone still be working here when I probably don't got no job because you're a nigger woman"

(Ballenger et al., 2017, p. 171). This blatant discrimination shows how some people in the

engineering workplace are uneducated in terms of diversity and inclusion. Jasmine's experience occurred in the workplace, but discrimination also occurs in the education system. Terri, a woman of color engineering student, received a grade of 69 on every assignment in an engineering class, which is both a sexual reference and a failing grade (Ong et al., 2020, p. 597). This professor, like many others, views engineering as a field for white men, so he treated Terri poorly because she is a minority woman. Minority women in engineering experience subtle and direct discrimination in education and the workplace, hindering their pursuit of engineering.

In addition to harassment, female minorities are victims of implicit bias and racial or gender stereotyping. Specifically in the hiring process, women of color are often discriminated against and not chosen for a job because of stereotypes held by members of the search committee. For instance, black women are stereotypically angry or aggressive, and Asian women are expected to be meek and submissive. Whether the search committee is aware of this or not, they draw on these stereotypes when considering a woman of color for an engineering job. One study discovered that "Black women with lighter skin were favored over Black women with darker skin during the selection process" (Liu et al., 2019, p. 33). These biases pose a serious challenge to female minorities pursuing an engineering career. Furthermore, many women of color strive to dispel stereotypes about themselves, causing them stress as they overcompensate. They feel the need to prove themselves more than white male engineers to gain the same amount of credibility and respect (Ong et al., 2020, p. 597). Stereotypes hinder minority females' mental health and, as a result, their engineering work. Implicit bias and stereotyping in the engineering workplace are substantial obstacles to women of color in the hiring process, everyday work, and overall health.

To combat discrimination and implicit bias, universities and workplaces could enforce a zero-tolerance policy for discrimination as well as implement diversity workshops and implicit bias training specifically regarding females of color. In an educational setting, universities could commission a woman of color speaker to make the campus aware of minority females' mistreatment in the engineering field. This event could inspire conversations and dialogue concerning the structural racism and sexism that perpetuates engineering programs, which in turn could inspire change in the attitudes of the engineering community. In the workplace, similar workshops could be held where women of color with engineering backgrounds are commissioned to speak on the subject of discrimination in the engineering workplace (Rincon & Yates, 2018, p. 24). Engineers would learn to recognize the ways that minority females are oppressed in the workplace and strive to counter this oppression in everyday life. By simply bringing awareness to this discrimination through diversity events and workshops, the engineering field will become more inclusive for women of color. Also, a zero-tolerance policy for racism and sexism must be implemented at both universities and workplaces (Kachchaf et al., 2015, p. 188). This policy would largely eliminate the blatant discriminatory jokes and harassment because the perpetrator's job is at risk. However, to protect white engineers, some universities and businesses might exclude women of color to avoid the confrontation altogether. This issue can be avoided by encouraging diversity through aforementioned workshops and partnerships with professional societies for women of color. Additionally, implicit bias training should be held periodically in engineering workplaces to dispel common stereotypes and harassment. According to Liu and her colleagues, the training should "focus on empirical research (e.g., providing information that disconfirms commonly held stereotypes) rather than emotional or moral appeals, provide procedures for countering bias, and use local climate

indicators" (2019, p. 33). Research shows that this training method succeeds at countering implicit bias and promoting diversity in the workplace. Stereotypes about women of color will be dispelled, creating a happier and safer workplace for these minority women pursuing engineering. When these workshops and trainings are implemented in engineering education and workplaces, the culture of engineering will transform, giving minority females more opportunities in the field.

Although implicit bias training promotes inclusion during the hiring process, women of color in engineering face a barrier to promotion through institutional housekeeping. For example, only 32.1% of black women in STEM are tenured at universities whereas 58.2% of white men in STEM are tenured at universities (Wu & Jing, 2011, p. 83). Institutional housekeeping refers to the service jobs that workers participate in that take away valuable time and effort from their actual research and professional career. These tasks could include teaching a class at a university, joining a specific committee, or taking on any role that is not part of their job. Women in STEM are asked to participate in institutional housekeeping activities three times more than men, and women of color are asked to do this even more (Liu et al., 2019, p. 36). Since few minority women pursue engineering, they are often overused and exploited in any activity related to diversity, inclusion, racism, or sexism. They may be asked to "teach classes related to racial-ethnic issues, serve on diversity-specific committees, mentor students of color and female students, and handle minority and gender affairs" (Liu et al., 2019, p. 36). For example, Tanya Foreman, a black engineer at Eastman Chemical Company, was automatically expected to record the notes at meetings simply because she was the only woman in the room, and a woman is expected to fill a secretary-like role (2020). These service jobs distract women of color engineers from their research that would typically lead to promotion or tenure in the workplace system.

Only five percent of head professors of STEM fields at four-year universities are people of color, both men and women, so women of color account for even less of this percentage (Frehill & Ivie, 2013, p. 10). Only one percent of Asian women working in the science and engineering industry are managers (Wu & Jing, 2011, p. 86). Both of these percentages are very small, and this is partly due to institutional housekeeping. Women of color are not promoted to esteemed positions in the workplace because of the time they devote to their additional service jobs. Institutional housekeeping is a significant barrier to promotion for women of color in the engineering workplace.

To counter the effects of institutional housekeeping, workplaces could establish an equal workload for all engineers, allowing for equal opportunity in terms of promotion and tenure. Workplaces should initiate transparency, and one research study suggested forming a dashboard "showing low, medium, and high teaching, advising, and service levels across campus and departments to better pinpoint unequal workloads" (Liu et al., 2019, p. 37). This dashboard is an easy way for workplace managers to become aware of the burdens that they place on each subordinate. They would refrain from asking the same woman of color to perform various service jobs because they know that would unequally distribute institutional housekeeping. By equally allocating the number of service jobs, women of color engineers will have time to focus on research that could eventually lead to advancement. Also, many promotion and tenure policies are unclear and unavailable, making it difficult for minority females to pursue a promotion in their career because they are unaware of the qualifications. To make this more transparent, workplace managers should conduct meetings clarifying the qualifications for tenure or promotion and openly publish these policies for reference (Liu et al., 2019, p. 37). Women of color in the engineering workplace will have equal opportunity for advancement in their careers

when workplaces publish an equal distribution of institutional housekeeping and policies on promotion and tenure.

On the other hand, some people say that women of color are just disinterested in the field of engineering, or that their culture minimizes the value on higher education in the science and mathematics fields. These people are drawing on stereotypes about women being drawn to the social sciences and people of color tending to be blue collar workers. Neither of these stereotypes are true in all cases, so they are invalid claims. However, these naysayers do have a point about women of color not being interested in engineering, but this is due to lack of opportunity by not introducing STEM topics early on in the education process. Diversity in engineering is "negatively impacted by inadequate science and mathematics training in the K-12 education system" (Ballenger et al., 2017, p. 159). To combat this lack of opportunity, proper science and engineering programs should be implemented in elementary and middle schools, especially in predominantly non-white schools. These opportunities could spark scientific interest for women of color at an early age, eventually resulting in more of these minority women pursuing engineering careers. Women of color are not simply disinterested in engineering, but they are not introduced to the subject early on in their education.

By implementing these solutions in the engineering education system and workplace, engineering culture will be forever altered to encourage more diversity and inclusion of minority females. An engineer's job is to propose possible solutions to problems in design, machines, and structures, and systemic racism and sexism could be approached as another problem that engineers must confront and solve. Although this issue is very different than what typical engineers face on a normal day, it is a significant issue nonetheless. Engineers need to use their problem-solving skills to eradicate racism and sexism in the field, using solutions already

proposed and creating new solutions of their own. In addition to these solutions, more research

must be completed to better understand the challenges that women of color engineers face and

the effectiveness of proposed solutions. Once universities and workplaces implement these

solutions, young minority girls will no longer face the same struggles that Mrs. Foreman faced

when pursuing her dream of becoming an engineer (2020). In modern engineering culture, it is

rare to discover a university or workplace where diversity and inclusion are practiced on a

regular basis, but Hongyou Lu has experienced a rare inclusive career as an Asian engineer. Mrs.

Lu attended the University of California Berkeley in pursuit of a master's degree in energy and

resources, which is a combination of mechanical, environmental, and electrical engineering.

During her educational career, she did not experience discrimination, at least not to her

knowledge and memory. In her classes, she encountered many women of color pursuing

engineering, including Middle-Eastern, African American, and American Indian women. This is

uncommon for a university, but Mrs. Lu attributed this to Berkeley's diverse campus and

background. She is currently the senior research associate for Lawrence Berkeley National

Laboratory, which is affiliated with the university, and she has a very similar experience in the

workplace as in her studies. She has many female engineering coworkers from very diverse

backgrounds, and she has rarely, if at all, experienced racial or gender harassment (2020). Mrs.

Lu's career is a very unusual experience in modern engineering culture, but this inclusive

experience should become the new norm. Engineering culture needs to change so that diversity

and inclusion of female minorities are of utmost priority, increasing their representation in the

field.

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