Board 137: Persistence of Women of Color in Undergraduate Engineering Programs

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Abstract

In 2018, the United States Bureau of Labor has predicted that the number of engineering related occupations will increase at a rate of 10 to 23% between 2018 and 2024. Moreover, women consist of nearly half of the workforce in the United States but only 14% of the engineering workforce. In order for the United States to meet the demand for qualified engineering professionals, underrepresented women will need to engage and persist in engineering educational pathways. The purpose of this descriptive qualitative research study is to explore how four female engineering students of color, in their junior and senior years, at a predominantly White institution describe their success and persistence in engineering. The study also explores how the role of gender and race can impact the engineering educational pathway for women of color. Findings from the study are congruent with current literature that acknowledges that women of color in engineering face additional challenges outside of the normal rigors of coursework such as experiences with prejudice, discrimination, and lack a sense of belonging. The findings also illuminated how gender roles and a lack of understanding about race are additional obstacles that women of color must overcome as they pursue their undergraduate degrees. By paying careful attention to how these young women navigate through their undergraduate engineering programs, we gain insight on why women of color persist and find success in engineering while facing added challenges related to race and gender.

Keywords: women of color in engineering; persistence; gender; race

Introduction

The United States Bureau of Labor Statistics (BLS) reported that in 2018, women accounted for 42.2% of careers in life, physical, and social science occupations and accounted for only 14% of architecture and engineering occupations. Additionally, African Americans and Latinos only account for 5.5% and 8.9%, respectively, in architecture and engineering occupations. Moreover, since BLS's employment growth report in 2016 projects an average increase of 4% in engineering careers, and up to 24% in some engineering fields, there is motivation to decrease the gender and racial disparity in engineering occupations. In order for the United States to meet the demand for qualified engineering professionals, educators and policy makers must explore the reasons behind the gender and racial disparities; and strive to increase the persistence and success of women of color in engineering.

While there has been an increase in women of color majoring in undergraduate engineering programs in the last 10 years, there is still disparity in degree attainment between underrepresented women and their White male counterparts [1]. Minority women, specifically African American and Latina women, may face additional challenges in undergraduate engineering programs outside of universal student experiences of feeling overwhelmed by the workload, learning engineering theory, and social adjustment to campus life. Many of these students encounter additional challenges such as differences in ethic/cultural values and

socialization, chilly classroom environments, perceived lack of faculty/advisor support, internalization of negative racial and gender stereotypes, and socio-economically disadvantaged background [2], [3], [4].

Typically, postsecondary educational research focuses on one element of engineering students such as gender or ethnicity; and fails to recognize the intersectionality of women of color. This is compounded by the fact that due to low participation, women of color in engineering are underrepresented in research [2]. Qualitative research can provide a means of understanding the issues that these young women face when pursuing their engineering degrees. By paying careful attention to how these young women navigate through their undergraduate engineering programs, we gain insight on why women of color persist and find success in engineering while facing added challenges related to race and gender. With this understanding, educators and policy makers may illuminate alternatives for improving retention and graduation rates for women of color in engineering.

The following qualitative analysis provides insight on how gender roles and a lack of understanding about race are additional obstacles that minority women must overcome as they pursue their undergraduate engineering degrees. Understanding how these women overcome these additional challenges and describe their own personal success, can contribute to improving educational support and retention, and increase graduation rates for these women. The study sought to answer the following research question: How do women of color describe their success and persistence in undergraduate engineering programs, including the role of personal qualities and social networks? The following is an examination of current literature with regards to challenges that women of color in engineering encounter, persistence of underrepresented minorities, and motivation in degree completion; a description of research methods utilized in this study; the study findings; and conclusions and implications for future research.

Literature review

While there are many factors that contribute to gender and racial inequality in science, technology, engineering, and mathematics (STEM) settings, the following research focused on social marginalization and the intersectionality of women of color in engineering [5]. As women enter engineering programs in pursuit of degree attainment, they may feel unwelcome, lack program support, and encounter negative gender stereotypes. Women of color face additional challenges outside of gender such as experiences with prejudice, discrimination, and differences in cultural values and socialization [3] that may hinder their confidence and effect their pursuit of an engineering degree [7].

Women of color attending predominantly White institutions (PWIs) may experience alienation and “chilly climate” in undergraduate engineering programs on two fronts, both by race and gender, which creates social marginalization from their peers [5]. “Chilly climate” is described as feeling unwelcome based on direct and indirect cues that engineering is a masculine profession, gender stereotypes that imply that women may lack ability, and subtle sexist messages conveyed by their classmates and faculty [5]. These feelings can be compounded by differences in cultural values and socialization, racial stereotypes, isolation, and lack of peer and faculty role models [3]. Even students who are highly capable and motivated academically can

be hindered by these experiences and question their value and lack of sense of belonging in engineering programs [5], [7]. In fact, chilly climate appears to specifically hinder women and Hispanic students in undergraduate civil engineering programs [8].

Students who experience this chilly climate may feel uncomfortable or find it difficult to reach out to faculty for support, which can negatively impact their academic success [3]. This is compounded by the fact that underrepresented minority engineering students are less likely to interact with faculty compared to their White male counterparts [9]. Underrepresented students may have perceptions that both White faculty and students believe them as having less capability academically, which can weaken their self-confidence and sense of belonging [10]. Additionally, minority students often miss opportunities of having faculty role models with similar ethnic and cultural backgrounds, as undergraduate engineering programs typically lack minority engineering faculty [9].

There is evidence that selected institutions are more successful at retaining and graduating underrepresented minority students in STEM disciplines [8]. The disparity in an institution's ability to foster success in minority students appear to be, in part, based on the quality of experiences that these students encounter. In fact, African American students in STEM majors are more likely to experience higher rates of success at historically Black colleges and universities (HBCUs) compared to non-HBCUs [11]. Students majoring in STEM disciplines at HBCUs are more likely to experience nurturing environments and reported higher levels of self-efficacy, content interest, and support than their peers at PWIs [8], [12]. Institutions with higher rates of persistence and graduation rates with STEM underrepresented minority students, report increased student involvement on campus, have welcoming environments, and encourage meaningful connections with faculty, which are all factors in fostering social-belonging [8]. Understanding how high-performing institutions create environments of social belonging and a sense of belonging can provide a plan to increase rates of success and degree completion for minority engineering students.

Evidence indicates that there is a relationship between campus involvement, particularly participation in minority organizations, and academic success for underrepresented minority students in STEM [9], [13]. Campus involvement in minority organizations can create social networks that consists of peers and mentors with similar cultural backgrounds that provides additional emotional and academic support outside of the classroom [13], [14]. The emotional and academic support network can provide students with sense of social belonging in the campus culture [15]. By having a sense of social belonging and creating positive social relationships, socially marginalized students can minimize feelings of isolation, loneliness, and low social status harm [14], [15] that women of color in engineering may face. In Palmer, Marahba, and Holmes' study [13], a Black female student majoring in industrial engineering stated that her involvement in National Society of Black Engineers (NSBE) aided her in finding a support system that was instrumental in her academic success.

An additional factor in the persistence of underrepresented minority students in undergraduate programs is positive relationships with members of engineering faculty [13]. Students who are able to create meaningful relationships with faculty members, outside of the classroom have reported higher levels of college satisfaction and persistence to graduation [16]. In fact,

underrepresented minority students who have persisted and completed engineering degrees have emphasized the instrumental role that faculty members have played in their academic success [16]. While research has highlighted the importance of minority students having faculty role models from similar cultural and ethnic backgrounds, undergraduate engineering programs typically lack underrepresented minority faculty members. However, White faculty members can make meaningful connections and play an important role in underrepresented minorities students' success at PWIs [13]. The academic success of Latino students, in particular, have been attributed to having supportive and accessible engineering professors regardless of their ethnicity [16]. For women of color in engineering, having a meaningful connection with female faculty members can provide academic support and role models that help students achieve their career goals [13], [16].

Research suggests that peer support is an important factor in creating a sense of belonging and supportive educational environment, which can contribute to the persistence and graduation rates for minority engineering students [3], [13]. While the majority of these relationships are formed in the engineering program and in campus minority organizations, peer networks outside of academics provide an important role in the success of students [2]. Minority engineering students often separate academic and social peer networks due to the limited number of minority students in engineering programs [2]. Palmer, Marahba and Holmes' (2010) study with undergraduate minority students found that friend support from peers outside of their major motivated them to persist and succeed in their undergraduate programs. Minority organizations, sororities and fraternities provide a social network that honors students' cultural backgrounds, while academic networks contribute to academic achievement [2].

While social integration in engineering programs and campus environment are critical, a students' motivation to persist in engineering can be fundamentally attributed to having positive perceptions of engineering and confidence in their technical skills; including engagement in mathematics and science courses [17]. In French, Immekus, and Oakes' study in predicting engineering student's success and persistence, they found that GPA and motivation were the most significate predictors [17]. Cole and Espinoza's study found that Latina students' persistence in engineering programs was related to their GPA; more so than their male counterparts [16]. These studies are consistent with literature that female students who major in engineering are academically prepared for the rigor of engineering programs (cite- Cole and Espinoza). However, women are more likely to have lower confidence in their abilities in certain student learning outcomes in engineering courses, such as design [7].

Existing literature regarding the intersectionality of women of color in engineering and insight on factors contributing to their academic success is limited, due to their low participation in engineering programs. This study aims to address the existing gaps in literature by examining how women of color at a PWI define success, and gain an understanding of how their experiences have impacted their engineering educational pathway.

Methodology

This qualitative study draws on interview data gathered as part of a multi-method research project on student-faculty interactions for students of color in engineering [18]. The study was

conducted at a public, large, four-year research PWI, located in an urban area in the southeast region. Approximately 2,500 undergraduate students were enrolled in the College of Engineering (COE) when data were collected. Fifteen percent of students enrolled in the COE are African American/Black, Hispanic/Latino, Native American, and Multi-racial; and nine percent are women. Participants were recruited through the COE and through campus entities and minority student organizations providing services to students of color. To be eligible for participation, students needed to meet specific criteria, including self-identification as African American/Black, Hispanic/Latino, or multi-racial including either of those identities; junior or senior standing in an engineering major and in good academic standing with the university; between 18 and 24 years of age; and be involved in extracurricular academic activities such as research, professional, or student organizations. Students received a modest incentive for their participation in this study.

Interview transcripts and demographic information on the participants was obtained, with permission, from the research project's principal investigators. Demographic data on race/ethnicity, gender, class rank, major, transfer status, and first-generation status for each participant were collected for the original study using a questionnaire. The demographic data for each participant were provided to the researchers in a table format to ensure further de-identification of participants. The interview criteria included questions about the participant's background, reasoning for majoring in an engineering discipline, personal qualities that have contributed to their success, academic and extracurricular experiences, interactions with faculty members and other forms of social capital outlined in the Community Cultural Wealth framework [19]. Specific student organizations, such as National Society for Black Engineers (NSBE) or Society of Hispanic Professional Engineers (SHPE), were de-identified in the transcripts. A summary of the participant's included in this study are provided in Table 1.

Table 1: Demographics of Women of Color in Engineering Participants in this Study

Participant ID	Ethnicity	Class	First-Generation	Major
1	Latina	Senior	Yes	Civil
2	African American	Senior	No	Civil Technology
3	African American	Junior	Yes	Electrical
4	African American	Junior	No	Systems

Data analysis was completed by coding the transcribed semi-structured interviews using inductive, descriptive coding strategies. The transcripts were imported into ATLAS.ti software to aid in coding the transcripts. Pattern coding was utilized during the second iteration of coding, from group codes into categories. The codes were used as evidence of emerging categories and themes. The categories were then utilized to create themes by looking for connections, relationships, and patterns from the participant's own words. A summary of the selected codes and quotes from the participants was exported from ATLAS.ti to organize descriptive codes, categories, and themes.

For qualitative studies, it is necessary to describe how the position of the researchers influenced data analysis and interpretation of the data [20], [21]. Two researchers conducted the data analysis portion of this study. One researcher is a Caucasian female engineer in higher education

whose research interests focus on persistence and retention of underrepresented engineering students. The second researcher is an African American female whose research focus is on the advancement of women of color in higher education.

Findings

Three major themes emerged from analyses of the interview transcripts: relationships and social networks outside of engineering major; motivation to persist; and campus environment. The data from this study is congruent to findings from existing literature with regards to campus involvement, faculty and peer relationships, and personal qualities that promote success in engineering. The findings also provide insight on additional challenges that women of color in engineering are faced with in their pursuit of degree attainment. While most women stated that they had not experienced racism directly on campus, several students inadvertently recounted racial microaggressions they encountered from their peers. Most of the women spoke about having to prove their worth or place in engineering due to their gender.

Theme 1- Relationships and social networks outside of engineering program

Participants noted how the encouragement and support of family and friends have aided in their success in engineering. Specifically, they expressed how having family members who have been to college or have work experience in engineering or construction has been most helpful. The range of reported family support varied from limited involvement to very supportive, and consisting of providing words of encouragement, inquiring about their studies, and providing financial assistance. One participant stated that her family did not encourage her, but trusted that she would be successful.

I guess, my whole life, I've been the smart kid. As far as my family goes and even in school, I've always been the smart kid.... They don't really push me, but they don't discourage me, either. It's kind of like, 'We know you got you, so we don't need to worry about you,' or do whatever, the necessities that parents will usually do. It's just, they know I got me and they know that I'm taking care of me. I've always been independent. So, it's nothing to really worry about. - African American, Senior (P2).

The other women expressed that while their families provided emotional and financial support, they did not understand the rigors of college and engineering. In particular, first generation students struggled with explaining their engineering program requirements and the level of effort required for assignments.

I would say even my [extended] relatives are really supportive of me. I have a huge family. I don't really talk to them about my experience in school because it's not something I can just explain to them…They always do say words of encouragement to me because that's all we can speak of…obviously they know I'm going through the process, but they don't know exactly what the process is.- Latina, Senior (P1)

One woman's mother and aunt did not necessarily support her decision to pursue engineering. The student stated that her mother thought that she would be working outside doing manual labor. She expressed a desire for the COE to host a social event where faculty members could explain to students' families what engineering is and the demands of being an engineering student. The student reported that she was concerned that her mother's lack of understanding could impact her younger sibling and steer her away from pursuing engineering.

I'm trying to encourage my sister because she's 13, and she's like she wants to do mechanical engineering, so I'm trying to just tell her from experience, because if I would have listened to my parents, I wouldn't have been in engineering, or not my parents, but my mother and her side of the family because they don't really understand that. - African American, Junior (P3)

Additionally, first-generation students expressed that their family members did not pressure them to succeed in college or to graduate. However, these students felt the weight of encouraging their young siblings to pursue higher education and explaining the requirements of being a college student.

I'm pressured in a sense that I have to show the younger generation what exactly is expected of them. – Latina, Senior (P1)

Many students noted the role that their peer network outside of engineering has played in their success. Women expressed that while their friends respected their need to stay in to study or complete assignments, they did not fully understand the demands of being an engineering student. Interestingly, students spoke about how their friends outside of engineering have motivated them to complete their engineering degrees since friends in other majors have found it difficult to find work after graduation.

My peers influence me sometimes indirectly…they basically show you why you should stick with engineering. A lot of people who I know that have graduated that haven't had engineering degrees, they have a hard time getting jobs. So when I hear them, it just kind of encourages me to keep doing what I'm doing. - African American, Junior (P4).

Many of the participants worked part-time at local engineering firms and were proud of their internships. In fact, being selected for competitive internships was an example that several students gave when talking about their success. Students noted how these opportunities provide additional skillsets that will set them apart as they graduate and seek full time employment in their careers. Although racial and gender disparity at these firms were observed by the students, one student expressed her resolve to not let it affect her. Interestingly, she noted that she was unbothered by hearing her coworkers talk about women, but that other women might not feel the same way.

The firm I'm working for now is basically all White, redneck, country type firm, but I try not to see color, because at the end of the day, everybody's here for the same thing. Everybody's either trying to make a difference or make a paycheck so I just see it as me trying to grow as an individual in my career and not just,… 'I'm the Black female in the room.' Yeah, they have little

moments where they talk about females and whatever, but it doesn't really bother me like it would bother other females. - African American, Senior (P2)

A senior engineer at a firm told one student that she will be hired exclusively based on her gender and race. There was an implication that she would have to work hard to prove that she deserved the job based on merit and skill. The weight of making a mistake and being thought of as not worthy for the job weighed heavy on her. This conversation carried over to her school work as well.

One guy, the head engineer at [company] said to me, 'Sometimes you'll get a job because they need to meet a certain quota. They need to meet their equal opportunity quota, but you want to show them that you know what you're doing as well.' Say, something goes wrong, and you're a trainee, it's, 'Oh, she did it, but she didn't know what she's doing. I mean, she looks like she doesn't know what she's doing.' To me, that's what they're thinking in their head. So you have to look over that and just work harder. I always keep that in the back of my head with everything I do, because if I do horrible on a test, I'm extra hard on myself. – African America, Junior (P3)

Theme 2- Personal qualities that promote success

Women spoke about how their love of mathematics was the key reason they decided to major in engineering. While they attributed their skill and confidence in mathematics as a factor, determination and the ability to communicate well were noted as key factors of their success. Students expressed that the key factor in measuring success is persisting to graduation from their respective engineering programs.

With engineering as long as you stay in it,… as long as you graduate, like that's successful because a lot of people start out in it, and whether they get discourage, or it's a lot, it's a very rigorous profession. I know some people just don't continue with it, you know. So, for me, success is honestly just getting a degree. - African American, Junior (P4)

Another student noted that her determination to graduate is motivated by her background and her desire to encourage others with the similar childhoods to strive for a more prosperous future. She described how attitude and having confidence are contributory in her success and drive to complete her engineering degree.

I came from a hood background. Everything. The whole nine, but I'm trying to better myself. I'm not trying to go back there. I'm trying to show the people there that you can be something. You can do better for yourself. It's just about your mindset and how you carry yourself, honestly. - African American, Senior (P2)

Another student echoed a similar sentiment about how the determination to succeed comes from within and that it is something you have to want for yourself. Specifically, she noted that she has no one to depend on and she must rely on her own will to persist.

I've never been able to really count on somebody my all my life. I feel like it comes from within, if you know you want to do something, you have to just set that in your head and do it, no matter what. – African America, Junior (P3)

Along with determination, students described how being an effective communicator has aided in their success in school and in being selected for internships. One student credited her ability to give effective presentations to gaining credibility as a professional. Specifically, she explained that in order to be taken seriously, one should not use slang.

I feel if you can explain what you do well, then I feel like they have a sense of thinking, 'Okay, she knows what she's talking about. She knows what she's doing.' I'm not just in engineering just to say I did it. You know how to speak to a professional or speak in a professional manner. If you get in front of a crowd, you know how to get up there and actually talk and not just sitting up there…using slang, which means you don't know what you're talking about.- African American, Senior (P2)

Students added that speaking to university faculty members in a professional manner has contributed to their success.

The way that I communicate with my professors, I think, has had a positive effect on everything. - African American, Junior (P4)

Theme 3- Campus environment

Women stated that they had noticed an increase in minorities on campus from when they first started at the university, however they also noted that there had not been the same increase in their engineering programs. Students noted the gender and racial disparity in their engineering courses; however, most stated that they did not feel isolated in class. They described specific interactions with their peers in their engineering classes. While they stated they did not feel alienated in class, they mentioned instances where they had to prove their worth in group work by earning higher grades or having a better understanding of assignments.

There were four groups and each group had about 20 students. I was the only chick, the only Hispanic in my group…I never felt alienated because…they've had troubles with their homework and they've come to me for suggestions. So, I don't consider myself as that far below them if they're coming to me for questions. – Latina, Senior (P1)

Another student expressed a similar sentiment of having to prove to her peers that she is just as capable, if not more so, by earning some of the top grades in her engineering classes. Interestingly, while she described how her male, White peers are mostly close-minded, she aligned herself as being closer with them than other women in the program.

Being in a major with church going rednecks who think one way, you have to remember, this is an engineering program, so most of the people in the program are kind of close-minded…It's not really an issue as far as me being Black. When you're female and you first get into this major, I feel like it's a hazing thing, in a sense. They got to make sure you can stand up for yourself. You

can handle being around them everyday, all day. I don't really take it seriously and it doesn't bother me. I'm closer with guys than I am with females. You would think the females would be like, 'Female power,' or whatever, but I'm closer with the guys. – African America, Senior (P2)

One student described how her peers have noticed her being self-critical in class and have asked her why she is so hard on herself. She explained that if she performs poorly on an assignment or test, then the implications of that failure are worse for her than her White, male peers. She further explained that she feels like minorities have more to prove than White people.

A White guy said… 'Why do you feel like you have so much to prove?' I was just like, 'I do. I just do. I just feel like if I do bad, it's three times worse than if you do bad, even if we get the same grade.' I have to stay mindful. I feel like I always have my guard up. I feel like no matter what, if say, a White guy, he can make a 20, but I make a 20 and I'm dumb, in everybody's mind…I just feel like Black people have more to prove, or minorities in general. – African American, Junior (P3)

Students concluded that due to the difficulty of their engineering courses, all of the students in their program, regardless of race or gender, are in it together. One student noted that she has had to explain her hair to several White, male students. She attributes this to a lack of understanding on the White students' part and not as an example of racism.

Having other friends in engineering can be a positive influence,… because you just got to stick together… Sometimes, it's just a lack of understanding. Like for example, the way I wear my hair sometimes may not be what most White students are used to seeing. I have been in situations like that where, people making comments about my hair or something like that. I just explain to them what being natural is and my hair changes a lot. – African American, Junior (P4)

The students gave their opinions on the relevance of racial discrimination and prejudice on campus. Many of the students explained while racism and discrimination will always exist, they had not experienced it directly on campus. Two students gave examples where they were unsure if they had experienced discrimination or racism blatantly, but possibly racial microaggressions. They both rationalized the experiences as a lack of understanding and not necessarily a negative event.

I don't think I've ever experienced [racism] …I think the only way it could be ignorance, I guess…like 'Oh, you're Hispanic. Let me help you with this,' or something like that…the only way that I would see somebody racist on campus. Outside of that, I don't see much racism. – Latina, Senior (P1)

I just know it's a different look to me in a hallway. When some old White guy walks down, and I walk down, 'What's she doing here?' You know? That's just me…I mean maybe they've never seen, or haven't seen in a long time, like, 'Is she supposed to be here?' But not in a negative way, just in general. I've noticed that, because I'm very observant. – African American, Junior (P3)

Another student stated that she thought Black students come in with a mindset that there will be racism against them, particularly based on the experiences of their parents and grandparents. She concludes that that is not the case and that White students do not care about their skin color.

I think the racism part is more so along the Black people than it is the White people, honestly. We already grow up with that mindset of Black Power movement. Our parents instill that into us growing up, because that's what they knew…, because we get in there and we have that hostile environment, when in reality the White person sitting next to you don't even care about you. They don't care about the color of your skin. – African American, Senior (P2)

While students stated that they had not experienced racial discrimination directly, several students expressed that they have experienced gender discrimination in their engineering courses. One student described how there was a rite of passage that women have to go through when they start in an engineering program to show that they are just as capable as men. Another student gave an example of men in her study group assuming that she would not have the same skills as them when working on a project.

I don't think race really has anything to do with it, but I think it was maybe like [being] female...in our freshman engineering classes, sometimes they don't let me do work. Like they don't want me to do certain stuff. Sometimes people are like, 'Oh she's a girl, you know, she don't know how to build stuff, or something like that and that's just lack of understanding. Once you see enough women do something better than you, then you will know that they can do it. I was the only girl in my group [in an engineering course]. Surprise. But when it comes to building stuff, …they were just like, 'No. We'll do it.' – African American, Junior (P4)

Students had varying interactions with engineering faculty that ranged from limited to classroom to having a supportive, meaningful relationship beyond the classroom. Students described efforts to engage with faculty in and outside of the classroom with varying outcomes. Some described faculty relationships being limited to classroom lectures and occasional homework support during the faculty members' office hours.

I don't really see much communication between professors and students unless you're doing a research project with them or asking them questions about your course. I don't think any of my professors are unreachable in that sense either. It's more of if you want to approach them, you can. Whenever I do want to contact a professor, it's usually because I have a homework problem. – Latina, Senior (P1)

Several students expressed feeling like their professors were too busy to help them with homework due to faculty members research responsibilities on campus. One student in particular stated that she felt like her professors were unapproachable and that it was not productive to go to their office hours for academic support. Another student described how faculty members were not invested in their students and had apathetic feelings towards her professors.

Indifferent, everyone is just doing what they're doing. A lot of teachers do research at the school… I hear that from my peers, they're like, 'Oh yeah, teachers do research here, they don't care.' – African American, Junior (P3)

Some students detailed having meaningful relationships with selected professors. These professors were described as approachable and available to students outside of office hours and provided academic and career support. One student in particular gave an example of a professor that has been a valuable resource for support and has given her career advice.

One interaction I had with one professor, ... he's very motivating. He just wants you to succeed honestly. That's really our goal. At least, that's his goal. I can't speak for everyone else. He's like, 'We just want you to succeed.' I didn't even know I could use him as a reference until after I got a job and he's like 'Did you use me as a reference?' I'm like, "No. I didn't know I could. He's just like, 'Well, you should have.'. – African American, Senior (P2)

In addition to supportive professors, another student described instances of their engineering departments providing support and contributing to a positive, welcoming environment. The student described how even the senior administrators in her engineering program were approachable and how she felt like she could go to any faculty member for academic support.

Everyone is a little more open and casual. I see the undergraduate director in the hallway on my way to class…If I have something I want to ask him I can definitely just go to his office. My experiences here have been a little bit more relaxed. I can just go in their [faculty] office and ask a question. I don't have to set an appointment or anything like that. – African American, Junior (P4)

Several students indicated that they conversed with faculty members differently than they did with their peers or family members. Students stated that it was important to sound professional and avoid using slang in order to be taken seriously by professors. The way that they spoke to professors, they considered it to sound more intelligent and an important skill to master.

You want them to respect you the same amount that you respect them. It's like you need to speak a certain type of way for them to even listen to you. They don't want to hear you talking slang because they're not going to listen to that…I don't think it's a negative thing. I think it's positive. Even with my friends, sometimes I'll tend to talk to them like I talk to my professors. It's like, 'Oh my gosh, you're really smart.' – African American, Senior (P2)

Several students engaged in professional organizations on campus, such as NSBE, where they had opportunities to build relationships with other undergraduate engineering students from similar ethnic and/or cultural backgrounds. The students described how these organizations have provided them significant campus, academic, career, and scholarship support.

[Student organization] has definitely helped me a lot. I've met a lot of great people through that organization. They've helped me a lot to develop as a professional rather than just a student...job interviewing, applying for jobs, how you must dress and present yourself, and how to do a little pitch to present yourself towards other companies. – Latina, Senior (P1)

Conclusions and Implications

Women and ethnic minority students often face isolation, lack of program support, and negative gender and/or ethnic stereotypes in their undergraduate engineering programs [2], [4], [5], [6], [7]. Understanding how these challenges impact their persistence and degree attainment is critical in finding solutions to aid in closing the gender and ethnicity gap in engineering. However, due to low participation in undergraduate engineering programs, research is lacking on the intersectionality of women of color. This qualitative study, while having a limited sample size, suggests that women of color adopt some individualistic, engineering-typical behaviors and mindsets [9], [13], [14] to persist and find success in their respective programs. Many of the women rationalized their experiences with negative gender stereotypes and racial microaggressions, as a lack of understanding instead of systemic factors or bias.

Several implications for future research and practice can be derived from this study. There is a need for additional studies at varied settings to understand the experiences of women of color in engineering. A longitudinal study with repeated interviews and conversations from freshman year to senior year could result in greater depth of exploration of experiences. This type of study could explore when women assimilate or adapt to engineering-typical behaviors or if they exhibit these behaviors prior to entering undergraduate programs. Additionally, studies of women who left engineering and how their experiences contributed to choice of another career of study might add to the depth of exploration of experiences.

Students' experiences from this study suggest that professors should be mindful when assigning group work, to ensure women, and women of color in particular, are not relegated to administrative tasks. Institutions should be more inclusive of their representations of "who is/can be an engineer" in all courses and academic clubs, not just affinity based ones. It is important for all students, especially White males, to be exposed to an academic engineering environment that is diverse and inclusive.

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