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The Experiences of Women and Other Minoritized Engineering Students at HBCUs: A Descriptive Phenomenological Study

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ABSTRACT

This article explores the unique experiences and challenges faced by women, African Americans, Hispanic/Latino, Native Americans/Alaskan Natives (AHN) AHN students pursuing an engineering degree program. Drawing from existing research and literature, the article examines issues such as underrepresentation, biases, and stereotypes that can impact the academic and professional experiences of these students. It also highlights strategies and resources that women and AHN students utilize to navigate these challenges and succeed in the field of engineering. The purpose of this phenomenological descriptive qualitative study is to explore AHN engineering students' experiences as they pursued their engineering programs, and to contribute to efforts to promote diversity and inclusion in the engineering profession.

Keywords: HBCUs Mentoring, Underrepresentation, Women in Engineering

INTRODUCTION/BACKGROUND

In this paper, the minority student members are described using the first alphabetic letters of African Americans, Hispanic/Latino, Native Americans/Alaskan Natives (AHN) to coin an abbreviation for the group. Also, we define minority groups as "any group of people who because of their physical or cultural characteristics are singled out from the others in the society in which they live for differential and unequal treatment, and who therefore regard themselves as objects of collective discrimination" (Hacker, 1951).

Engineering is a critical field that plays a significant role in shaping our world. Engineers are responsible for developing and designing innovative solutions to complex problems, ranging from transportation to energy and healthcare. Despite the critical role that engineering plays in society, historically the field has been primarily male (Office of Science and Technology Policy, 2016). Women, as well as African Americans, Hispanic/Latino, and Native Americans/Alaskan Natives (AHN) have, and still, face significant barriers and challenges in pursuing and advancing in engineering careers (Skvortez, 2020). Women and African Americans, Hispanic/Latino, Native Americans/Alaskan natives are not represented in engineering education as their counterparts when viewed from their percentage in the US population (National Academies of Sciences, 2018). The underrepresentation of women and AHN in engineering has important implications for the engineering field. The lack of diversity in engineering can limit the range of perspectives and ideas that are brought to bear on engineering problems (Secules, 2017). It can also result in a failure to address the needs of diverse communities and can limit the creativity and innovation that engineering can bring to society.

According to the National Science Foundation report for Women, Minorities, and Persons with Disabilities in Science and Engineering of 2023, 10% of the engineering workforce with a degree are Hispanic, 8% are Black, and 0.2% are American Indian or Alaska Natives, this describes the low representation of AHN members. Altogether, there was a slight increase in the representation of AHN members, these AHN members were only 14% of the workforce population with a science and engineering degree this year. While comparing the first National Science Foundation for Women, Minorities, and Persons with Disabilities in Science and Engineering report of 1982 with the newest edition of 2023, it is evident that one of the findings did not change. This is the relatively small percentage of women and AHN

graduates that are earning degrees in science and engineering (Diversity, 2023).

Also, several studies on Black and Hispanic students have been carried out in predominantly white universities (PWI's). Although, research has proven that black and Hispanic students attend and succeed more in Historically Black Universities and Hispanic serving colleges, graduating higher numbers of Black and Hispanic students (Fleming et al., 2013). Hence, a phenomenology study on understanding the lived experiences of women and African Americans, Hispanic/Latino, and Native Americans/Alaskan Natives in an HBCU engineering programs will provide insight to help guide the known factors that aid or obstruct the success of women and AHN members in engineering (Henderson et al., 2021).

Engineering plays a significant role in developing and designing innovative solutions to complex problems, from transportation to energy and healthcare. Historically, the field has been primarily male. Women, as well as African Americans, Hispanic/Latino, and Native Americans/Alaskan Natives (AHN), still faced significant barriers and challenges in pursuing and advancing engineering careers (Office of Science and Technology Policy, 2016). According to Skvortez (2020), Women and African Americans, Hispanics/Latinos, and Native Americans/Alaskans are not adequately represented in engineering education. Comparatively, White/Male counterparts maintain higher percentages in the US population (National Academies of Sciences, 2018).

The underrepresentation of women and AHN in engineering has significant implications for the engineering field that can limit the perspectives and ideas brought, including assessing engineering problems (Secules, 2017). Research on exclusionary challenges fails to address diverse communities' creative contributions to innovation engineering for society. According to the 2023 National Science Foundation report for Women, Minorities, and Persons with Disabilities in Science, 10% of the engineering workforce with a degree are Hispanic, 8% are Black, and 0.2% are American Indian or Alaska Natives; this describes the low representation of AHN members. Altogether, there is a varied increase in the representation of AHN members; 14% of the workforce reflects science and engineering degrees this year. Comparatively reporting for the National Science Foundation for Women, Minorities, and Persons with Disabilities in Science and Engineering for 1982 and 2023, it is evident that there are few variations in marginalization representation, showing a relatively small percentage of women and AHN graduates earning degrees in science and engineering (Diversity… 2023). Therefore, this phenomenology study on understanding the lived experiences of African American, Hispanic/Latino, and Native American/Alaskan Native

women in engineering programs seeks to provide insight into the known factors that aid or obstruct the success of marginalized members in engineering (Henderson et al., 2021).

Several scholars have also submitted that women and minorities continue to decrease at higher cadres of academia, in engineering fields and other STEM disciplines (Stachl, & Baranger, 2020). For example, the Digest of Education Statistics, 2019, reported that 8.9% of women with a bachelor's degree in engineering, got employed in engineering career in 2019, while 20.9% of men with a bachelor's degree in engineering got employed in engineering career. Hence, the engineering field continues to be primarily White male (Digest of Education Statistics, 2019). Although the percentages of African Americans, Hispanic/Latino, Native Americans/Alaskan Natives minorities in engineering graduates slowly increases, their representation is still lower than their representation in the US population. More importantly, the representation of African Americans, Hispanic/Latino, Native Americans/Alaskan Natives faculty in four-year colleges and research-oriented universities is lower than expected compared with the individuals with a Ph.D. (Stockard, et al. 2021). In 2016, the representation of tenure-track faculty in higher ranked departments had only 6% that identified as AHN (Oxide, Open Chemistry …, 2020). This continued underrepresentation of minorities and women in engineering in the U.S will result in a problem for the economic security of the U.S (Holdren & Lander, 2012;), the U.S defense (Defense Advanced Research Projects Agency, 2010), and for the U.S. social equality development (Rattan, et al., 2018).

In addition, scholars have explored the process of using higher educational institutions to increase the representation of AHN and women in engineering. In this study, we explore the lived experiences of women and AHN members as they go through engineering programs. Our aim is to add to the body of knowledge on inclusion and diversity in the engineering profession. However, there is limited study available of scholars that explored the experiences of women and AHN engineering students using a phenomenological approach. Furthermore, this paper explores the experiences of women and AHN members in engineering, with a focus on identifying the barriers and challenges that they face in pursuing and advancing in their engineering degree program.

By better understanding these experiences, we can develop strategies to address the challenges that women and AHN face while enrolled in engineering programs and promote greater diversity and inclusion in the field. To achieve this goal, this paper draws on a qualitative approach, including structured questionnaire protocols distributed to women and AHN members who are engineering students at four Historically Black Colleges and

Universities (HBCU). The paper is structured as follows: first, we provide an overview of the research on underrepresentation of women and AHN in engineering; second, we present the methodology used in the study; we employed Paul Coallizi's phenomenology theory to gather and analyze the data. Third, we present the findings of the study; and finally, we discuss potential strategies for addressing the challenges identified and promoting greater diversity and inclusion in engineering.

Scholars researching women and minorities continue to note a decrease in higher cadres of academia, engineering fields, and other STEM disciplines (Stachl & Baranger, 2020). The 2019 Digest of Education Statistics reported that 8.9% of women were employed with a bachelor's degree in engineering, while 20.9% of men were employed with a bachelor's degree in engineering. Hence, the engineering field continues to be primarily White male (Digest of Education Statistics, 2019). Although the percentages of African American, Hispanic/Latino, and Native American/Alaskan Native minorities in engineering graduates are slowly increasing, their representation is still lower than their representation in the U.S. population. This is a result of the study of Bonous-Hammarth that focused on STEM program undergraduate enrollment and retention, which concluded that Black, Hispanic, American Indian students were less likely to enroll in STEM programs than their Asian or White counterparts.

Bonus went further to conclude that those Black, Hispanic, American Indian students that eventually choose STEM majors were also less likely to finish in the STEM degrees and get their diplomas in STEM (Bonous-Hammarth, 2000). More importantly, the representation of African Americans, Hispanic/Latino, and Native American/Alaskan Native faculty in four-year colleges and research-oriented universities is lower than expected compared to individuals with a Ph.D. (Stockard et al., 2021). In 2016, in the representation of tenure-track faculty in higher-ranked departments, only 6% of these faculty identified as women and AHN minority groups (Oxide, Open Chemistry …, 2020). This continued underrepresentation of minorities and women in engineering in the U.S. will result in a problem for the economic security of the U.S. (Holdren & Lander, 2012;), the U.S. defense (Defense Advanced Research Projects Agency, 2010) and for the U.S. social equality development (Rattan et al., 2018)

In addition, scholars have explored using higher educational institutions to increase the representation of AHN and women in engineering. In this study, we explore the lived experiences of women and AHN members as they go through engineering programs. The researcher aims to add to the knowledge of inclusion and diversity in engineering. However, a limited

number of studies are available from scholars that explore the experiences of women and AHN engineering students using a phenomenological approach.

Furthermore, this paper explores the experiences of women and AHN members in engineering, focusing on identifying the barriers and challenges they face in pursuing and advancing in their engineering degree program. By better understanding these experiences, we can develop strategies to address women's and AHN's challenges while enrolled in engineering programs and promote greater diversity and inclusion in the field. This paper draws on a qualitative approach to achieve this goal, including structured questionnaire protocols distributed to women and AHN members who are engineering students at four Historically Black Colleges and Universities (HBCUs).

The paper is structured as follows: first, we provide an overview of the research on the underrepresentation of women and AHN in engineering; second, we present the methodology used in the study; we employ Paul Coallizi's phenomenology theory to gather and analyze the data. Third, we present the study's findings; finally, we discuss potential strategies for addressing the identified challenges and promoting greater diversity and inclusion in engineering. The research question being studied is: what is the essential structure of the experiences of women and AHN engineering students as they study to become engineers?

LITERATURE REVIEW

Only 3% of the United States two- and four-year higher education colleges are historically Black colleges and universities (HBCUs). However, it is important to note that over 24% of all Black African American college graduates received their degree from an HBCU (U.S. Department of the Interior, n.d). Importantly, HBCUs contribute to the U.S. workforce, there are 40% of Black African Americans in the United States congress, the percentage of black African American lawyers in the U.S is 50%, and 80% of the judges in the U.S, graduated from an HBCU (Camera 2017). Although the enrollment of students in HBCUs in 1980 was 230,000, as of 2015 the number of students enrolled in an HBCU was just 293,000. This growth is at a very slower rate than the growth in predominantly white colleges and other two and four year colleges in the U.S (Anderson 2017). Also, HBCU colleges produce a good portion of the STEM degrees earned by Black African Americans, with 31% of biology science and math degrees (U.S. Department of the Interior, n.d).

Scholars have made concerted efforts to understand the causes of race and gender disparities in STEM education and to offer solutions. Considering the figures presented earlier on women and AHN minority groups representation in engineering, one can conclude that women and AHN

minority groups are minorities in engineering. A factor that leads to the minority of students of color is, when they perceive a negative racial campus climate, their academic persistence and retention rates fall (Reid & Radhakrishnan, 2003; Rodgers & Summers, 2008; Worthington, Navarro, Loewy, & Hart, 2008). These circumstances foster negative experiences for women and AHN students giving them hostile learning experiences in their engineering programs affecting these students' academic performances and retention rates. Contrarily, if women and AHN students are in an higher institution with positive racial environment, this will help them build a solid sense of belonging that leads to better academic performance and retention rates for black students (Booker, 2007; Goodenow, 1993; Hinderlie & Kenny, 2002; Strayhorn, 2008).

Some researchers investigated how higher institutions maintain a color-blind ideology that cultivates eliminating negative practices for minority students (Gusa, 2010; McGee, 2016; Museus et al., 2015; and Reason and Evans, 2007)). For example, Black students and Latinix students have described feelings of having to prove their ability to belong compared to their peers. They also reported being referred to by their peers as "affirmative action" students (Camacho & Lord, 2011; McGee & Martin, 2011). Furthermore, the qualitative study of Camacho and Lord, (2011) investigated how black women in engineering programs described experiencing sexist and racist microaggressions in their higher institutions, among their peers and with their faculty. Since the earlier studies of Pierce in 1970 and 1978, several scholars have reported the continuous existence of racism in colleges (Coates, 2011; Dovidio, Dina, 2021; Gaertner, Kawakami, & Hodson, 2002; Meggan, et. al., 2020; McConahay, 1986; Sears, 1988; Smith, 1995; Sue, Capodilupo, & Holder, 2008).

Only 3% of the United States' two- and four-year higher education colleges are historically black colleges and universities (HBCUs). However, over 24% of all Black/African American college graduates received their degree from an HBCU (U.S. Department of the Interior, n.d). HBCUs significantly contribute to the U.S. workforce. According to Camera (2017), 40% of Black African Americans are part of the United States Congress, with 50% and 80% serving as judges, all graduates from HBCUs. Since 1980, HBCU enrollment has increased from 230,000 to 293,000 in 2015. Comparatively, the growth of HBCUs is slower than that of predominantly white institutions (PWIs) and other two- and four-year colleges in the U.S. (Anderson, 2017). Nonetheless, HBCUs continue to produce an exemplary portion of the STEM degrees earned by Black/African Americans, with 31% in biology, science, and math (U.S. Department of the Interior, n.d).

Scholars have made concerted efforts to understand the causes of race and gender disparities in STEM education and to offer solutions. Several scholars have posited that engineering education programs are less likely to retain women and AHN students at every stage in the pipeline (Blackburn, 2017; Carver et al., 2017; Drew et al., 2016; Estrada et al., 2016; Smith et al., 2023). The engineering field records the highest gender disparities in higher education, higher than computer science, mathematics, biology, and chemistry (Master, et al. 2021). However, reporting for women and AHN minority engineering highlights the factors that led to the minority students of color perceiving adverse racial bias in campus climate and needing persistence for academic retention (Reid & Radhakrishnan, 2003; Rodgers & Summers, 2008; Worthington et al., 2008). Additional circumstances for women and AHN students foster an increased hostile learning environment for engineering programs and affect these students' academic performances and retention rates.

Inspite of the fact that Latinx population has increased to be the highest number of minority groups in the US, they are a small percentage of the engineering students (Garcia-Felix, 2019). Studies on the experiences of undergraduate Latinx engineering students have generally been grouped with other undergraduate engineering students of color, and although these minority groups have some things in common, to effectively develop successful programs to attract and retain Latinx engineering students, the distinguishing experiences of these Latinx students, the barriers to success, should be adequately researched (Espinoza, 2013; Rincón, et al., 2020). Just in the way that African American students are more likely to gain more benefits by enrolling in HBCUs than PWIs, the Hispanic students are also more likely to gain more benefits attending Hispanic serving institutions. As of 2004, there was an increase in the HSI's in the United States, increasing to 366 HSI's; the increase was about three times more that it was ten years earlier. HSIs at that time registered 63% of all the Hispanic students in colleges and 27% of all the underrepresented minority students in higher education in the U.S (Li & Carroll, 2007). Also, in the year 1992, the National Center for Educational Statistics reported that the Hispanic student's persistence rate in colleges and universities was the higher than any other minority group in the US. The major element that appeared to correlate with the Hispanic student's academic persistence in higher education was their perceptions of their university environment and cultural congruity (Fleming, et al., 2013).

Additionally, Researchers have submitted that cultural identification, Tinto's model of social integration into colleges and commitment of Black African American students are more likely factors that determine their

decision to enroll and finish from HBCUs. Also, when researchers controlled pre-collegiate features and the academic selectivity of the university, studies submitted that attending an HBCU is positively linked with African American students continuing in higher education and obtaining a bachelor's degree (Kim, 2000; Wolf-Wendel, 1998). More importantly, the research of Allen posited that the "fit" connecting African American students and higher education is more suitable at HBCUs. Also, Wenglinsky found that Black students at Black institutions are more likely to become professionals (Wenglinsky, 1996, Kim, 2002). Hence, women and AHN students that are in a higher institution with a positive racial environment; this will help them build a solid sense of belonging that leads to better academic performance and retention rates for black students (Booker, 2007; Goodenow, 1993; Hinderlie & Kenny, 2002; Strayhorn, 2008).

Some researchers investigating academic matriculation maintain a color-blind ideology that cultivates eliminating harmful practices for minority students (Gusa, 2010; McGee, 2016; Museus et al., 2015; Reason and Evans, 2007; Smith et al., 2023). For instance, Black students and Latinx students have described feelings of having to prove their ability to belong compared to their peers in PWI's. They also reported being referred to by their peers as "affirmative action" students (Camacho & Lord, 2011; McGee & Martin, 2011). Furthermore, the qualitative study of Camacho and Lord (2011) investigated how black women in engineering programs described experiencing sexist and racist microaggressions in their higher institutions, among their peers, and with their faculty. Since the earlier studies of Pierce in 1970 and 1978, several scholars have reported the continuous existence of racism in colleges (Coates, 2011; Dovidio, Dina, 2021; Gaertner et al., 2002; Meggan et al., 2020; McConahay, 1986; Sears, 1988 Smith, 1995).

Influences on Persistence and Success in Engineering

Studies have shown that the decision to pursue a career in engineering starts before enrolling in college, because having an engineering identity is linked to developing the identity from a very young age (Bieri Buschor et al.2014; McCarthy and Berger 2008). Having supportive families (Burge 2013; Lee 2016; Lyon 2013), having access to quality advising (Byars-Winston 2014; Bystydzienski, Eisenhart, and Bruning 2015), early engineering education classroom environments (Han 2016), and exposure to gender-inclusive video games (Bonner 2015; Gilliam et al. 2017) contributes to having an engineering identity. Several scholars suggest that social status, economic status, and academic preparedness of students are contributory elements to persistence and success in engineering.

Recently, there have been on-going strategies to recruit women and AHN students into undergraduate engineering programs (Skvoretz, et al. 2020). However, several of these strategies have resulted in failed recruitment endeavors (Blackburn, 2017; Wang & Degol 2016), factors like social capital (Lyon 2013; Thackeray 2016), institutional structures (Bottia et al. 2015), poor advising (Lee 2008), leads to these failed attempts. Also, research has demonstrated that the low representation of women and AHN students in engineering are reasonably due to implicit factors that are not related to interest and aptitude (Margolis, Fisher, & Miller 2000; Skvoretz, et al. 2020; Hill, Corbbet, St. Rose 2010; Sax 2008; Shapiro and Sax 2011; Summers and Hrabowski III 2006). An example is the study of Seymour and Hewitt (1997), their result found that students that switch away and students that do not switch away from engineering were not distinguishable in how they prepared in high school, either in their efforts contributed, or in their performance scores. Eventually, what made the difference were the challenges students encountered that were related to the engineering program's structure and institutions culture that recorded having high effect on persistence in the engineering program.

Earlier studies submitted that the levels of social capital of the students may influence students' academic success. For example, AHN students without the right resources may not be aware that academic preparation for courses in engineering may need to have been started by middle school (Bishop, 2015; Hilton et al. 1989; Clewell, Anderson, & Thorpe 1992). Also, adequate access to engineering career information (Clewell, Anderson, & Thorpe 1992) had effects on preparedness (Seymour and Hewitt 1997). Importantly, African Americans, Hispanic/Latino, Native Americans/Alaskan Natives students often do not have role models in their faculty and mentors and also do not have other students that look like them (Brown 1994), therefore, these students feel alone and do not feel they belong as they pursue their engineering program, giving them different experiences from their other course mates (Litzler and Samuelson 2013; Marra et al. 2012; Seymour and Hewitt 1997). The study of Marra et al. (2012), concluded that African American students and women had the same reason to switch away from engineering programs. Some of these reasons were, having no sense of belonging, poor advising, poor teaching, and difficult curriculum. Evidently, African American students alluded to having no sense of belonging and a difficult curriculum in influencing their switch than other groups. More importantly, the motivation to persist of women and AHN students were influenced by their capacity to attract specific strategies, their perspectives on academic and personal support that kept them motivated (Seymour and Hewitt 1997).

The Influences of a Healthy Student-Faculty Relationship

The study of Tyson, Smith, and Ndong (2010) demonstrated that faculty and administrators of students who switched out of engineering programs differed in their opinions on the students' non-success in their engineering programs. The scholars submitted that the administrators and faculties' opinion was that the students' academic preparedness in high school was influential to their academic success. However, a few students who demonstrated having appropriate academic preparedness said they switched away from engineering because they did not have the right information about the expectations in their engineering program (Tyson et al.; 2010). The result of Tyson, Smith, and Ndong (2010) posited that some students who switched away from engineering programs did not understand how pivotal success in mathematics in their high school classes was or they were not informed or guided to take the required sequence of courses. Hence, these results show that when the student's gain confidence and social capital from faculty, advisors, or mentors, this can play a vital role in preparation and persistence of the AHN and women students.

Also, the research of Seymour and Hewitt (1997) posited that the role of social supports cannot be overemphasized in helping engineering students deal with the challenges they come across as they pursue engineering programs. In fact, several women and AHN students reported that belonging in professional societies encouraged them to persist in engineering programs and also gave them access to resources needed for success (Borman, Halperin, & Tyson 2010; Chanderbhan-Forde, Heppner, and Borman 2012). Besides, the analysis of the experiences of the switchers' indicated that they "did not know what to expect" before they started an engineering program (Tyson, Smith, & Ndong 2010). Hence, the effect of having role models, faculty, advisors with more knowledge of engineering provided vital information that shaped the students' persistence and success for African American students and women in engineering programs (Seymour and Hewitt 1997; Borman, Halperin, and Tyson 2010; Chanderbhan-Forde, Heppner, and Borman 2012). African American students mostly describe their experience as encountering homophily which influences how the students form relationships with their faculty and how they form study groups (Skvoretz, et al. 2020).

In general engineering programs that do not adopt healthy student-faculty relationships giving reasons to 'weed-out' students contributed to making it very difficult for women and AHN students' success in their early years of their program. Seymour and Hewitt (1997) reported that several

interviewees described heartbreaking experiences that affected pursuing their engineering program, leading to depression, burn out times, and confusion. The students eventually sought for advisors and faculty counsel asking if it was worth continuing the program. The students at these points placed their future career in engineering on the advice given by their faculty or advisor. Often, the 'Care-less' replies of the advisor proved to be a breaking point for women switchers. Women who pursued engineering programs explained that having a personal relationship that was supportive with their faculty or advisor encouraged them greatly, and they reported that the gender of the faculty was not important in meeting this need (Seymour and Hewitt 1997). Also, Poor and Brown (2013) submitted that having women engineers as mentors for women engineering students increased the retention rate of women engineers. The students described having these relationships build their sense of belonging with engineering as a career and boosting their confidence in succeeding in an engineering program. The mentors encouraged the students in their professions as engineers and performed roles of networking and providing vital information leading to successful engineering programs.

Factors that Affect Women and AHN students Preparedness

The studies used for this literature review established that there are factors beyond the students' academic preparedness and social factors that affect the successes of women and AHN students pursuing engineering programs. Therefore, women and AHN students need to have faculty, advisors, mentors to help them attain confidence and sense of belonging in engineering programs and help them conquer the challenges they encounter as they pursue engineering programs.

Although, academic preparation and social factors are contributory elements to the success of these students, the major factors that leads to lower number of women and African Americans, Hispanic/Latino, Native Americans/Alaskan Native students in engineering are caused by elements that are not related to the students interest and aptitude (Acker & Feuerverger, 1996; Hill et al., 2010; Margolis et al. 2000; McGee, 2020; Sax, 2008; Seymour, 1999; Shapiro & Sax, 2011; Summers & Hrabowski III, 2006). The result of the study of Riegle-Crumb et al. (2019) demonstrated that African American and Latino students were more likely to switch away from engineering major courses, however, when social factors and type of institution were controlled, the trend for students that were Latino disappeared. When the academic preparation factor was controlled, it did not change the increased likelihood switch away from engineering major for African American high school students (Riegle-Crumb et al., 2019).

Also, the study of Seymour and Hewitt (1997) showed that women and AHN students' preparedness and aptitude levels did not influence their switch away from engineering courses; rather, students switched away from engineering programs because they were disappointed in the engineering field, lost confidence that they could succeed in engineering, or lost interest in engineering. Weston (2019) revisited the Seymour and Hewiit (1997) study and discovered that students who switched away from engineering courses described not feeling a sense of belonging made them not fit in socially with engineering or not finding help to resolve the challenges they experienced that caused their switch away from engineering. In conclusion, this study's discovery put emphasis on the engineering department's climates 'programs culture' as the major cause of students switching away from engineering, different from the results of previous studies that laid emphasis on the students' preparedness causing the switch away from engineering (Skvoretz, et al. 2020).

Studies have also shown that the decision to pursue a career in engineering starts before enrolling in college because having an engineering identity is linked to developing the identity from a very young age (Bieri Buschor et al., 2014; McCarthy & Berger, 2008). Having supportive families (Burge, 2013; Lee, 2016; Lyon, 2013), having access to quality advising (Byars-Winston, 2014; Bystydzienski et al., 2015), early engineering education classroom environments (Han, 2016), and exposure to gender-inclusive video games (Bonner, 2015; Gilliam et al., 2017) contributes to having an engineering identity. Several scholars suggest that students' social status, economic status, and academic preparedness contribute to persistence program rigors and success in engineering careers.

There have been recent strategies developed to increase recruiting efforts of women and AHN students into undergraduate engineering programs across the United States (Skvoretz et al., 2020). However, several of these strategies have often failed (Blackburn, 2017; Wang & Degol, 2016), factors like social capital (Lyon, 2013; Thackeray, 2016), institutional structures (Bottia et al., 2015), poor advising (Lee, 2008), led to failed attempts. Also, research has demonstrated that the low representation of women and AHN students in engineering is due to implicit factors that are not related to interest and aptitude (Margolis et al., 2000; Skvoretz et al., 2020; Hill et al., 2010; Sax, 2008; Shapiro & Sax, 2011; Summers and Hrabowski III 2006).

According to Seymour and Hewitt (1997), researchers in engineering highlighted that students who switched from away to not away from engineering were not distinguishable in how they prepared in high school due to personal efforts in performance scores. The research of Seymor and Hewitt's participant recordings, narratives revealed that they encountered

challenges within the program's structure and the institution's culture, which highly impacted the women and AHN groups persistence in their engineering program. Earlier studies have submitted that some of these challenges are results of the levels of social capital of the students that influence the students' academic success.

For instance, AHN students without the proper resources may not be aware that academic preparation for courses in engineering may require early review labs in middle school (Bishop, 2015; Hilton et al., 1989; Clewell et al., 1992). Also, adequate access to engineering career information (Clewell et al., 1992) affected preparedness (Seymour & Hewitt, 1997). Notably, African American, Hispanic/Latino, and Native American/Alaskan Native students often do not have role models in their faculty and mentors and also do not have other students who look like them (Brown, 1994). Therefore, these students feel alone and do not feel they belong as they pursue their engineering program, giving them different experiences from their other classmates (Litzler & Samuelson, 2013; Marra et al., 2012; Seymour & Hewitt, 1997).

Mentorship and Advising

Research has shown that 53% of engineering and other science, technology and mathematics students engage in research activities as they pursue their degree (Marquez, & Garcia, 2021). Hence, mentoring and advising are pivotal activities that prepares engineering students to be successful in completing their program. The students in the data for this study sought for advisors and faculty counsel during their program, asking if the program was worth continuing. The students at these points placed their future engineering careers on the advice their faculty or advisor gave. These mentors encouraged the students in their engineering professions, performed networking roles, and provided vital information leading to successful engineering programs. Often, the 'Careless' replies of the advisor proved to be a breaking point for women switchers. Women who pursued engineering programs explained that having a personal relationship that was supportive of their faculty or advisor encouraged them immensely. Seymour and Hewitt (1997) reported that the gender of the faculty was not crucial in meeting their academic goals. However, Poor and Brown (2013) submitted that having women engineers as mentors for women engineering students increased the retention rate of women engineers. The students described having these relationships build their sense of belonging with engineering as a career and boosting their confidence in succeeding in an engineering program.

Therefore, women and AHN students need faculty, advisors, and mentors to help them attain confidence and a sense of belonging in

engineering programs and help them conquer the challenges they encounter as they pursue engineering programs. Although academic preparation and social factors are contributory elements to the success of women and African American, Hispanic/Latino, and Native Americans/Alaskan Native, lower number interest and aptitude scoring are not related to engineering preparedness (Acker & Feuerverger, 1996; Hill et al., 2010; Margolis et al., 2000; McGee, 2020; Sax, 2008; Seymour,

Sense of Belonging

The study of Marra et al. (2012) concluded that African American students and women had the same reason to switch away from engineering programs. Some of these reasons were needing more sense of belonging, poor advising, poor teaching, and a challenging curriculum. African American students alluded to having no sense of belonging, and a problematic curriculum influenced their decision to switch. More importantly, the motivation of women and AHN students to persist was influenced by their capacity to attract specific strategies and their perspectives on academic and personal support that kept them motivated (Seymour & Hewitt, 1997). Tyson, Smith, and Ndong (2010) demonstrated that faculty and administrators of students who switched out of engineering programs differed in their opinions on the students' non-success in their engineering programs.

Tyson, Smith, and Ndong (2010) submitted that the administrators' and faculty's opinion was that the student's academic preparedness in high school was influential to their academic success. However, a few students who demonstrated appropriate academic preparedness said they switched from engineering because they needed the correct information about the expectations in their engineering program (Tyson, Smith, and Ndong, 2010). The result of Tyson, Smith, and Ndong (2010) posited that some students who switched away from engineering programs needed to understand how pivotal success in mathematics in their high school classes was or were not informed or guided to take the required sequence of courses. Hence, these results show that when the students gain confidence and social capital from faculty, advisors, or mentors, this can play a vital role in the preparation and persistence of the AHN and women students.

Additionally, research by Seymour and Hewitt (1997) posited that social support should emphasize helping engineering students deal with the challenges they come across as they pursue engineering programs. Several women and AHN students reported that belonging to professional societies encouraged them to persist in engineering programs and also gave them access to resources needed for success (Borman et al., 2010; Chanderbhan-Forde et al., 2012). Besides, the analysis of the switchers' experiences

indicated that they "did not know what to expect" before they started an engineering program (Tysonn et al., 2010). Hence, the effect of having role models, faculty, and advisors with more knowledge of engineering provided vital information that shaped the students' persistence and success for African American students and women in engineering programs (Seymour & Hewitt, 1997; Borman et al., 2010; Chanderbhan-Forde et al., 2012). African American students mostly describe their experience as encountering homophily, influencing how they form relationships with their faculty and study groups (Skvoretz et al., 2020). Seymour and Hewitt (1997) reported that several interviewees described heartbreaking experiences that affected the pursuit of their engineering program, leading to depression, burnout times, and confusion. Also, Seymour and Hewitt's (1997) study showed that women and AHN students' preparedness and aptitude levels did not influence their switch away from engineering courses; instead, students switched away from engineering programs because they were disappointed in the engineering field lost confidence that they could succeed in engineering, or lost interest in engineering. Weston (2019) revisited Seymour and Hewitt's (1997) research for students who switched away from engineering courses and described not feeling a sense of belonging made them not fit in socially with engineering or not find help to resolve the challenges they experienced that caused their switch away from engineering.

Additionally, Riegle-Crumb et al. (2019) research demonstrated that African American and Latino students were more likely to switch away from engineering major courses when social factors and the type of institution were controlled. However, the trend for students who were Latino disappeared. When the academic preparation factor was controlled, it did not change the increased likelihood of switching away from an engineering major for African American high school students (Riegle-Crumb et al., 2019). In conclusion, this study's discovery emphasized the engineering department's climate' programs culture' as the primary cause of students switching away from engineering, different from the results of previous studies that emphasized the students' preparedness causing the switch away from engineering (Skvoretz et al., 2020).

In summary, the studies used for this literature review established that there are factors beyond the student's academic preparedness and social factors that affect the success of women and AHN students pursuing engineering programs. 1999; Shapiro & Sax, 2011; Summers & Hrabowski III, 2006). In general, engineering programs that do not adopt healthy student-faculty relationships, giving reasons to 'weed out' students, contributed to making it very difficult for women and AHN students to succeed in the early years of their program.

RESEARCH METHOD

Even though a few scholars have used Paul Coalizzi's phenomenology method to carry out research in public health, (Owoo, et al. 2022), there have not been a study using this phenomenology approach to explore the experiences of women and AHN groups as they pursue engineering programs. Researchers Rolbiecki, et al., (2023) used a phenomenological approach in their digital storytelling narrative study. Generally, this approach has been used in health, customer service, and entrepreneurial education only. The researchers of this study conducted a focus group discussion session with the participants guided by Paul Colaizzi's descriptive phenomenological approach. Thirty-five engineering students attended a workshop, and the focus group interview was carried out after the workshop.

Although, a few scholars have used Paul Coalizzi's phenomenology method to carry out public health research (Owoo, et al. 2022), Coalizzi used the phenomenology approach in psychology of learning research (Coalizzi, 1969). Apperently, there has not been a study using this phenomenology approach to explore the experiences of women and AHN groups as they pursue engineering programs. Researchers Rolbiecki, et al., (2023) used a phenomenological approach in their digital storytelling narrative study. Generally, this approach has been used in health, customer service, and entrepreneurial education only. Husserl was called the founder of descriptive phenomenology. He's descriptive phenomenology is widely used in health research to explore human experiences. Colaizzi's approach, positioned within Husserl's phenomenology, provides a way to analyze data and develop reliable findings (Zahavi, 2003). However, the researchers of this study conducted a focus group discussion session with the participants guided by Paul Colaizzi's descriptive phenomenological approach. Thirty-five engineering students attended a workshop, and the focus group interview was conducted afterward.

Descriptive phenomenology is a systematic process of explicating or bringing to awareness human beings' lived experiences on a particular phenomenon as reflected on and described by them. Lived experiences is at the center of phenomenological inquiry, the purpose of which is to explicate the fundamental meanings or essences of the phenomena experienced in the concrete lifeworld of people (Van Manen, 2016). The core of phenomenology is the connection between lived experience, the meaning of lived experience in the process of creating one's sense of being, and what it is to be human. Assumptions underlying such an approach to inquiry are as follows: humans create social networks; humans can describe retrospective and prospective life events; patterns and themes surface through intense study of phenomena

(Parse, 2001). Explanation of patterns and themes serves as a gateway for gaining access to a phenomenon's fundamental essence through the prism of lived experience (Murdoch et al., 2020).

Participants of this study were enrolled undergraduate and graduate students in four-year engineering HBCU college programs in the US. These programs are generally categorized as four- year programs leading to a bachelor's degree; however, some students may take longer than four years to graduate (American Society for Engineering Education, 2016). Also, some of our participants were graduate students. The participants for this study were 35 engineering students enrolled in four HBCU colleges. Eligible participants were students who registered for the workshop. The interviews were conducted during the 2020 calendar year, so students were at the end of the first year in their engineering programs or starting their second year.

Using Paul Coalizzis approach, a research question was coined, data was collected via interviews, and 35 students were interviewed using focus group interviews. The students were asked questions relating to their experiences as engineering students. Follow-up questions were asked when the students discussed statements of interests concerning experiences as engineering students. A member of the authors then read through the data to digest the data at different times. Then significant statements were highlighted from the participants' discussion of their experiences. The author used the Dedoose application to organize the significant statements that were grouped as codes. Further care was taken to analyze the significant statements and meanings were formulated using creative insights to express what the participants' statements meant (Tatano Beck, 2019). These formulated meanings are then organized to form themes and sub-themes. These themes were then reread to validate them with the original transcripts and with the participants.

Some of the questions asked were "How did you come to choose engineering or engineering technology? Who or what influenced you to make this choice?", "What difficulty did you encounter during your study, if any?", "How did you navigate your way through college? What people, event, experience, or program enabled you to overcome the challenges?", "Do you have a mentor in your institution and what role do you think they can play in helping you pursue a successful career?".

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is the connection between lived experience, the meaning of creating one's sense of being, and what it is to be human (Zahavi, D. (2003). Assumptions underlying this approach and inquiry are as follows: humans create social networks; humans can describe retrospective and prospective life events; and patterns and themes surface through intense study of phenomena (Parse, 2001). Explanation of patterns and themes is a gateway for gaining access to a phenomenon's fundamental essence through the prism of lived experience (Murdoch et al., 2020).

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helping you pursue a successful career?". The table below (table 1) shows the demographics of the participants of this study.

Table 1
Distribution of participants

Category	Female	Male	Black or Black American	Hispanic
Undergraduate	9	10	17	1
Graduate	4	2	6	0
Community college	1	1	0	0
Not specified.	4	4		

RESULTS

The questions asked during the interview discussions to gather data for this study was developed to elicit the participants experiences as women and AHN members in engineering programs. The data gotten was analyzed thematically and the table below displays some of the experiences of the participants in their engineering programs at HBCU's.

Table 2
Participant experience themes

Theme	Definition	Formulated meanings	Illustrative quote
Being Minority	Being the only or one of a few students who are African Americans, Hispanic/Latino, Native Americans/Alaskan Natives engineering students		"A lot of the time I was one of the only females in my classes. It would sometimes feel isolated. I had a lot of male classmates that would recognize it and make it less separated. Due to me being one of very few females in

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			my department, I struggled a lot with some of my male professors. I was also home sick majority of my freshman year being an out of state student."
Lack of same race mentors	Some students discussed not finding mentors of the same race to help them either in their institutions or around them.	No same race mentors in my Institution	"When I first started my college career at the university of XXX, I noticed I was different to the point where I felt alone. In my engineering classes, there were no other Native Americans. I even questioned if I was on the right path. It was until I heard about a club for Native American STEM students that I found my fellow peers."
Poor Time Management	The students discussed having poor time management.		"My greatest difficulty, not just in engineering, but in life as well, is poor time management. It's a crutch that I have, in my years of academia, learned how to navigate somewhat, but cracks still show up and I tend to fall back into

			procrastination and distractions. Having peers that keep me in check and using scheduling/planning have helped me steady myself back on track."
Limited preparation for the Job Market.	Some of the students discussed that they do not feel prepared enough for the job market.	Feeling inadequately prepared to take on engineering jobs.	"In my opinion because I haven't worked in the industry yet, I don't know exactly what the companies would be looking for, the skills and abilities I bring to the table are what I believe will make me marketable to someone's business. I previously stated that the University of XXX gives its students that first push, and it's up to the student to take those next steps, such is the same for parents, peers, and many other people that want to see you do well."
Pressure of being negatively evaluated by faculty	Having 'difficult' faculty who assume and negatively evaluate students' potentials in excelling in their course		"Sometimes being looked over as if I wasn't either not going to be able to understand or do it before the work was presented to me, more so

| | | | misogynistic prerogative that they know what we can do before we can show ourselves." "Learning Electronics, and Embedded Systems, first learning how to program and hesitancy if I had the mathematical aptitude for the field." |
| Innate Motivation | Students who just love and have passion for engineering subjects leading to motivating them to succeed in engineering. | | "I consider myself a motivated and working student, so I strive to always build on my skills, I believe given my exposure to some of these workshops and other activities I developed plenty of good soft skills, but I am currently building on my hard skills like working with certain programs and applying certain subject materials to the job." "It has always been an interest and passion of mine. Technology in general has drawn me". |

| Having Peers as Mentors | Some have their peers as their mentors. | | "My unofficial mentor XXX is an up-and-coming senior majoring in mass communications." "Although we have different majors XXX is a black young woman navigating through the world, and just from watching and speaking with her I learn how to handle, sometimes uncomfortable and unfortunate, situations. I believe the things she has taught me will help me learn how to handle situations professionally and properly without getting out of character. She has taught me that when a situation arises, I need to take myself out of the equation and look at all of the outcomes and see who it effects. Although these skills are ones I can use in life, when you hone them in a career amazing things will get done." |

Limited Access to Technology	Access to technology difficulties and other difficulties related to software access and acquisition.	"inconsistencies that accompany virtually learning engineering as a discipline." "Gaining skills and certifications that would make me a more viable job candidate like learning how to use CAD" "limited internet access."
Peer Group Study Support	Students formed peer groups to help support each other academically and in other ways.	"I always say if it weren't for my two best friends I wouldn't know where I'd be. They were like the yin and yang on my shoulders. One is a criminal justice student, barely had homework and partied a lot. The other was another mechanical engineering student and was determined to graduate and get a job. The criminal justice student taught me how to unwind, relax and to take a mental break while the M.E. my best friend was my study buddy. We struggled together, pushed each other, and truly supported

| | | | each other through my last few years." "Peers helped by just keeping me on track and being a listening ear/shoulder to cry on during those rough times." |
| I do not have a Mentor in my University | Students not having mentors in their universities. | | "Unfortunately, I do not have a mentor in my institution. I feel like the part a mentor plays in helping with a successful career is they help with connections, work etiquette, and how to maneuver through the various obstacles, life throws at individuals." "I have not had the pleasure of connecting with a mentor just yet. However, I intend to do so once returning to campus in Fall" "Not at my current institution" "I do not have a specific mentor." |

DISCUSSION

This article adds to the increasing literature on the experiences of women and AHN students in engineering programs. This study specifically adds to the body of knowledge by focusing on the perspectives of women and AHN students in HBCU engineering programs. There is a need for scholarly articles exploring the essential structure of lived experiences of women and AHN students in HBCUs. Historically black colleges are fertile ground for investigating women and AHN students' support in engineering programs. As predominantly white institutions developed structured systems of support to increase their students' success, it is pertinent for HBCUs to have good information to better support women and AHN students in engineering programs to increase their retention and graduation rates. With the increase in the literature on broadening participation for women and AHN members, the data gathered on the lived experiences of these members in HBCUs can provide helpful strategies to increase quality support for women and AHN students in engineering programs (Henderson et al., 2023)**.**

The essential structure of women and African Americans, Hispanic/Latino, Native Americans/Alaskan Natives' engineering students' experiences as they pursue engineering programs is complex and laden with challenges. Overall, the experiences of women and AHN students pursuing an engineering major can be nuanced, shaped by a range of social, cultural, and institutional environmental factors. However, with the right support and resources, these students can overcome challenges and succeed in their engineering academic and professional pursuits.

It is important for women and African Americans, Hispanic/Latino, Native Americans/Alaskan Native students to feel a sense of belonging and have an identity with engineering prior to getting into college. Research has shown that women and AHN groups can defeat the challenges like bias, and stereotypes by developing their individual self-confidence, self-efficacy, and a good sense of belonging to engineering early (Blackburn, 2017). As data from this study and several scholars have established, women and AHN students pursuing an engineering major often face unique challenges and experiences that can differ from their male and non-AHN counterparts. These challenges range from a lack of representation and support in the field to biases and stereotypes about their abilities and interests. This is evident in the themes from the data of this study, "I do not have a Mentor in my University" "Pressure of being negatively evaluated by faculty". Our data however shows that earlier identity with the engineering profession and having same race mentors is effective in increasing success in engineering programs. Previous scholars have demonstrated that women and AHN students depend on themselves to succeed in their engineering programs, they develop innate

commitment abilities to seek out resources to help them succeed by themselves (Henderson et al., 2023).

'Innate Motivation', one of the themes from the data of this study, confirms the claims in the literature review on women and AHN groups in engineering (Huang et al., 2021; Mobley & Brawner, 2019; Samuelson & Litzler, 2016). This is evident because research has shown that women and African Americans, Hispanic/Latino, Native Americans/Alaskan Native groups are motivated to pursue engineering careers because they have high personal interests in engineering (Skvoretz et al, 2020; Le & Robbins 2016).

These categories of people are attracted to careers that offer opportunity to help others, associating with people and have communal goals (Diekman et al. 2010, 2017; Diekman, Weisgram, & Belanger 2015; Edzie 2014; Fuselier & Jackson 2010; Su & Rounds 2015). Furthermore, researchers have reported that sometimes there are different motivations for women minorities to decide on engineering careers (Kolo 2016; Skvoretz et al, 2020). Ray (2016) concluded that Black American women were more influenced by religious leaders, their confidence in their abilities in engineering, and the reputation of the university, than their non-black peers were.

"Innate motivation" to pursue engineering is generally one of the popular themes in the literature for women and AHN groups. Women and AHN students that thrive in engineering programs have innate motivation that drives their resolve to be successful in engineering programs. Meanwhile, creativity, innovation and productivity and diversity in the workforce contributes to creativity, productivity, innovation, and success in engineering institutions. Women and AHN students in engineering have the drive to be innovative, productive, and creative fueled by their innate motivation to succeed in engineering. "Women's experiences, AHN, along with men's experiences should inform and guide the direction of engineering and technical innovation" (Corbett and Hill 2015, pp2). Besides, for the United States to continue being at the forefront in engineering, it is important to incorporate women and African Americans, Hispanic/Latino, Native Americans/Alaskan Natives' creativity and innovation to shape future engineering designs (Skvoretz et al, 2020; National Science Foundation 2017). Besides, the lack of representation of women and African Americans, Hispanic/Latino, Native Americans/Alaskan Natives in engineering leads to these students losing out on some high paying job opportunities.

One of the biggest challenges for women and AHN students pursuing an engineering major is the underrepresentation of their same race mentors in the engineering field. This can lead to the feelings of isolation and a lack of representation, which can hinder their ability to connect with peers and find

mentors who can support them in their engineering academic and professional pursuits. A theme from the data of this study that reflects this challenge that women and African Americans, Hispanic/Latino, Native Americans/Alaskan Natives groups face is "lack of same race mentors".

The role that mentors play in shaping the career of engineering students cannot be over emphasized. Also, this is evident in another of the themes obtained from the data of this paper "Being Minority" in the engineering programs or schools the students are in. This lack of representation can perpetuate stereotypes about women and AHN students, which can negatively impact their confidence and sense of belonging in the field. Another challenge is the persistence of biases and stereotypes about women and AHN students in engineering. These biases can manifest in subtle ways, such as assumptions about their abilities or interests (evident in the theme from data of this study "Pressure of being negatively evaluated by faculty"). These and more overt forms of stereotypes, such as discrimination or harassment affect the success of women and AHN students in engineering. These biases can create barriers to success and make it more difficult for women and AHN students to advance in their engineering programs. Despite these challenges, many women and AHN students in engineering find ways to overcome these obstacles and thrive in their field. They often rely on supportive networks, such as student organizations or mentorship programs, to connect with peers and mentors who can offer guidance and support. This is evident in one of the themes from the data of this study ("Having "Peers as Mentors" and "Peer Group Study Support"). These women and AHN students were left with choosing mentors from their peers and forming support groups amongst themselves.

The theme 'Lack of same Race Mentors' described the students not having mentors in their institutions leading them to the theme 'Peer Group Study Support' describing that the students sought mentors in their peers. However, the study of 'O'Donnell and Cunningham (2015) recommend interactive engagement between faculty and women and AHN students during and after class sessions, outside classroom tutoring sessions, psychological mediations, and continuous 'check in' with these AHN groups to certify that these AHN groups have the support needed to succeed in engineering. There should be retention endeavors that encourage positive faculty behaviors and support that leads to strong relationships with the faculty, academic advisor, or mentor (Blair et al. 2017, 14–43; Gayles & Ampaw 2011; Santiago 2012). Having female faculty, or African Americans, Hispanic/Latino, Native Americans/Alaskan Natives faculty representation in the engineering department, doing research and teaching also encourages retention of women

and African Americans, Hispanic/Latino, Native Americans/Alaskan Native engineering students (Vieyra, Gilmore, and Timmerman 2011; Wilker 2017).

Consistent with other scholars on women and African Americans, Hispanic/Latino, Native Americans/Alaskan Native groups, we submit that there are other factors than academic preparation that impact the success of women and African Americans, Hispanic/Latino, Native Americans/Alaskan Native groups in engineering programs (Margolis, Fisher, and Miller 2000; Skvoretz et al, 2020). The themes 'being minority', 'Lack of same Race Mentors' and 'poor time management', are sample themes from the data of this study that affirms that women and AHN groups need more than academic preparation to succeed in engineering programs.

There is a need for scholarly articles exploring the essential structure of the lived experiences of women and AHN students in HBCUs. This study adds to the increasing literature on the experiences of women and AHN students in engineering programs, by focusing on the perspectives of women and AHN students in HBCU engineering programs. Historically black colleges are fertile ground for investigating women and AHN students' support in engineering programs. As predominantly white institutions developed structured support systems to increase their students' success, it is pertinent for HBCUs to have good information to support women better and AHN students in engineering programs to increase their retention and graduation rates. With the increase in the literature on broadening participation for women and AHN members, the data gathered on the lived experiences of these student's in HBCUs can provide helpful strategies to increase quality support for women and AHN students in engineering programs (Henderson et al., 2023).

The essential structure of women and AHN students' experiences as they pursue engineering programs are complex and laden with challenges. In general, the experiences of women and AHN students pursuing an engineering major can be nuanced and shaped by social, cultural, and institution's environmental factors. However, with the proper support and resources, these students can overcome their challenges and succeed in their academic pursuits. It is essential for women and AHN students to feel a sense of belonging and identify with engineering before going on to college.

Research has shown that women and AHN groups can defeat challenges like bias and stereotypes by developing their self-confidence, self-efficacy, and a good sense of belonging to engineering early (Blackburn, 2017). As data from this study and several scholars have established, women and AHN students pursuing an engineering major face unique challenges and experiences that can differ from their male and non-AHN counterparts. These challenges range from lacking representation and support needs to biases and

stereotypes about their abilities and interests. In the themes from the data of this study, participant responses on "I do not have a Mentor in my University" and "Pressure of being negatively evaluated by faculty" show that earlier identity with the engineering mentors that share racial experience is compelling for success in engineering programs.

Previous scholars have demonstrated that women and AHN students depend on themselves to succeed in their engineering programs; they develop innate commitment and abilities to seek out resources to help them succeed by themselves (Henderson et al., 2023).'Innate Motivation,' one of the themes from the data of this study, confirms the claims in the literature review on women and AHN groups in engineering (Diekman et al., 2010, 2017; Diekman et al., 2015; Edzie, 2014; Fuselier & Jackson, 2010; Huang et al., 2021; Mobley & Brawner, 2019; Samuelson & Litzler, 2016; Skvoretz et al., 2020; Le & Robbins, 2016; Su & Rounds, 2015). Although, some researchers have reported that sometimes there are different motivations for women minorities to decide on engineering careers (Kolo, 2016; Skvoretz et al., 2020). Ray (2016) concluded that religious leaders have influenced more Black American women, increased their confidence in their abilities in engineering, than their non-black peers.

Several studies have submitted that women and AHN students who thrive in engineering programs have innate motivation that drives their resolve to be successful in engineering programs (Diekman et al., 2010, 2017; Diekman et al., 2015; Edzie, 2014; Fuselier & Jackson, 2010; Huang et al., 2021; Mobley & Brawner, 2019; Samuelson & Litzler, 2016; Skvoretz et al., 2020; Le & Robbins, 2016). This innate motivation in these women and AHN students in engineering leads to their innovativeness, productiveness, and creativity.

However, "women's experiences, AHN students' experiences, along with men's experiences, should inform and guide the direction of engineering and technical innovation" (Corbett and Hill 2015, pp2). Besides, for the United States to continue being at the forefront of engineering, it is crucial to incorporate women and African Americans, Hispanic/Latinos, and Native Americans/Alaskan Natives' creativity and innovation to shape future engineering designs (Skvoretz et al., 2020; National Science Foundation 2017). Besides, the lack of representation of women and African Americans, Hispanic/Latino, Native Americans/Alaskan Natives in engineering leads to these students losing out on some high-paying job opportunities.

One of the major challenges for women and AHN students pursuing an engineering major is the underrepresentation of same-race mentors in the engineering field. This lack of same race mentors leads to the minority students feeling of isolation, having a lack of representation, hindering their

ability to connect with peers and find mentors who can support them in their engineering academic and professional pursuits. A theme from the data of this study that reflects this challenge, that women and African Americans, Hispanic/Latino, Native Americans/Alaskan Natives groups face is "lack of same race mentors." Mentors' role in shaping engineering students' careers must be balanced.

Additionally, one other theme this paper produced, "Being Minority," in the engineering programs or schools the students are in, highlights one of the points in the literature review on lack of representation for women and AHN students. This can perpetuate stereotypes about women and AHN students, which can negatively impact their confidence and sense of belonging in the engineering field. Another similar challenge is the persistence of biases and stereotypes about women and AHN students in engineering. These biases can manifest subtly, such as assumptions about their abilities or interests (evident in the theme from data of this study, "Pressure of being negatively evaluated by faculty").

These and more overt forms of stereotypes, such as discrimination or harassment, affect the success of women and AHN students in engineering. These biases can create barriers to success and make it more difficult for women and AHN students to advance in their engineering programs. Despite these challenges, many women and AHN students in engineering find ways to overcome these obstacles and thrive in their field. They often rely on supportive networks, such as student organizations or mentorship programs, to connect with peers and mentors who can offer guidance and support.

The data used for this study showed in one of the themes that, "Having "Peers as Mentors" and "Peer Group Study Support" in their engineering programs encouraged these women and AHN students in their programs. The data for this study showed that women and AHN students were left with choosing mentors from their peers and forming support groups among themselves. However, the study of 'O'Donnell and Cunningham (2015) recommends interactive engagement between faculty and women or AHN students during and after class sessions, outside classroom tutoring sessions, psychological mediations, and continuous' check-ins' with these AHN groups to certify that these AHN groups have the support needed to succeed in engineering. There should be retention endeavors that encourage positive faculty behaviors and support that leads to solid relationships with the faculty, academic advisor, or mentor (Blair et al., 2017, pp. 14–43; Gayles & Ampaw, 2011; Santiago, 2012).

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and African Americans, Hispanic/Latino, Native Americans/Alaskan Native engineering students (Vieyra et al., 2011; Wilker, 2017). Consistent with other scholars on women and African Americans, Hispanic/Latino, Native Americans/Alaskan Native groups, we submit that there are other factors than academic preparation that impact the success of women and African Americans, Hispanic/Latino, Native Americans/Alaskan Native groups in engineering programs (Margolis et al., 2000; Skvoretz et al., 2020). The themes' being minority', 'Lack of same Race Mentors,' and 'poor time management' are sample themes from the data of this study that affirm that women and AHN groups need more than academic preparation to succeed in engineering programs.

CONCLUSIONS

We noted that the challenges to AHN and women engagement in their engineering programs, cannot be addressed by the students themselves. Rather, these are systemic problems that universities, and categorically, engineering program administrators must take care of. Knowing that although women in engineering are increasing (not equally with their counterparts) and African Americans, Hispanic/Latino, Native Americans/Alaskan Natives students', their representation in engineering continues to be stagnant in engineering (Roy, 2019), the students in this study describe difficult terrain that they go through as they pursue their programs in engineering. The students' description recommends that expanding the rate of AHN and women students declaring a major in engineering alone is not sufficient to increase the students' persistence.

Scholars have reported that women and AHN students are mostly not aware of "unofficial" pathways to having success in STEM programs (Campbell-Montalvo, et al 2022; McGee, 2020; Seymour, 1999; Stevens et al., 2008). Here are some pivotal implications for practice. First, given the difficult experiences of women and AHN students and how it affects persistence in their engineering program, it is pivotal for engineering programs to execute structural programming early at the start of the program in the first year to expose AHN and women students' and give them access to resources needed to be successful in engineering.

Hence, there should be interventions and strategic programs that expose women and AHN students to important resources, mentors and knowledge that will lead to the students' persistence (Atman et al.,

2008; Daily et al., 2007; Goodman et al., 2002; Shapiro & Sax, 2011; Stevens et al., 2008). Notably, colleges should employ nuanced methods when thinking of improving the experiences of women and AHN students' collectively. More importantly, colleges should provide African American students with more resources because of their differential experiences when compared with other AHN students (Blosser, 2020; Lee et al., 2020; McGee, 2020).

Secondly, because many of the students do not acknowledge the statuses of discrimination, and racial prejudice, does not mean universities should not provide interventions to build engineering minority student capital. It is important to link up students with similar students' status like them (Kricorian et al., 2020). The study of Blosser (2020) reported grouping students with similar statuses with the same race mentors yields positive experiences for women and AHN students, leading to the students developing healthy relationships with students that look like themselves (Ong et al., 2018), or by faculty that look like them to facilitate their persistence.

Unfortunately, because of the lack of sufficient diversity in engineering, most universities cannot provide homophilous mentorship for women and AHN groups of students (McGee, 2020). However, if homophilous mentorship for women and AHN groups of students is not possible, McGee (2020) reports that other faculty that is not similar with the student's race, gender and ethnic group with the students can still provide pivotal guidance to the students if they are aware on how students ethnic group, and gender stereotype influences the students. Engineering programs, and engineering institutions should showcase participatory-based program designs to encourage AHN students early engagement in professional engineering society and also encourage diversity, equity, and inclusion efforts in engineering programs (Peters et al., 2021), This will help women and AHN students to connect with possible mentors who share the same ethnic/racial, gender statuses with them (Campbell- Montalvo et al., In press; Campbell-Montalvo et al., 2020; Smith et al., 2021).

Lastly, university administrators and engineering program administrators have tried to solve the engineering inequality problem by employing individualized, deficit designed methods and situating the problem on the students (Peck, 2020), hence, keeping the racist

system untouched (McGee, 2020; McGee et al., 2021). To solve this problem, we recommend that universities and program coordinators develop interventions for women, AHN, and dominant groups, including the students and faculty. These interventions should be structured to recognize microaggression, injustice, stereotypes and raise awareness about them. Furthermore, these Intervention programs should help the dominant groups to recognize the effect of, what they say, their actions, their behaviors to women and AHN groups (Blosser, 2020). Although exposing these groups may not directly influence behavior, structural stereotype, policy, raising awareness will help the university to help how members of the majority group act towards women and AHN students.

Employing this method challenges the narrative that labels the students who are women or AHN as the problem. More importantly, these approaches should help the dominant groups be responsible and accountable of what they say and do (McGee, 2020), and to enlighten them on how to be good partners and to be supportive of women and AHN groups (Moore & Nash, 2021). Finally, engineering faculty and administrators should develop coursework that supports women and AHN students talking about engineering identity, increasing awareness programs on collaboration instead of individualistic values, and promoting a department ruled by a "success together" ideology to foster persistence of women and AHN (Campbell-Montalvo et al., 2020). This will encourage students to collaborate and network among themselves to work on their engineering identity together to increase their confidence in engineering.

The systemic problems for women and AHN students in engineering programs address barriers of inequality in U.S. universities. However, women and AHN students surpass academic enrollment, yet their representation still needs to grow in these STEM fields (Roy, 2019). The expansion barrier is student persistence through mentors in faculty and staff advising. Scholars' research for women and AHN engineer programs highlights that students are primarily unaware of "unofficial" pathways to success in STEM programs (Campbell-Montalvo et al., 2022; McGee, 2020; Seymour, 1999; Stevens et al., 2008). However, this information is pivotal to career development and has implications for learning.

Considering the structural consequences, programming early in the first year will expose women and AHN students to greater access that may be required in engineering careers. Hence, strategic programs necessitate interventions for women and AHN students that include resources, mentors, and knowledge that will further the students' persistence (Atman et al., 2008; Daily et al., 2007; Goodman et al., 2002; Shapiro & Sax, 2011; Stevens et al., 2008). Colleges should employ methods that improve the experiences of women and AHN students. More importantly, colleges should provide marginalized students with diverse resources based on their varied cultural and ethnic experiences -this includes identifying the ethnic groups they serve and providing more significant needs to African American students over Hispanic/Latino, Native American/Alaskan due to cultural hardships (other AHN students (Blosser, 2020; Lee et al., 2020; McGee, 2020).

Secondly, because many of the students do not acknowledge the status of discrimination and racial prejudice, universities should not build engineering programs based on minority student capital. Therefore, providing student engagement supports students' status like theirs (Kricorian et al., 2020). Blosser (2020) reported that grouping students with similar statuses with the same race mentors yields positive experiences for women and AHN students, leading to the students developing healthy relationships with students who look like themselves (Ong et al., 2018) or faculty who look like them to facilitate their persistence. Unfortunately, because of the lack of sufficient diversity in engineering, most universities cannot provide homophilous mentorship for women and AHN groups of students (McGee, 2020).

However, homophilous mentorship for women and AHN groups of students is not possible. In that case, McGee (2020) reports that other faculty members who are not like the student's race, gender, and ethnic group with the students can still provide pivotal guidance to the students if they are aware of how students' ethnic groups and gender stereotypes influence the students. Engineering developing programs and engineering institutions should showcase participatory-based program designs to encourage AHN students' early engagement in professional engineering society and also encourage diversity, equity, and inclusion efforts in engineering programs (Peters et al., 2021); this will help women and AHN students to connect with possible mentors

who share the same ethnic/racial, gender statuses with them (Campbell-Montalvo et al., In press; Campbell-Montalvo et al., 2020; Smith et al., 2021). Finally, university administrators and engineering program administrators have tried to solve the engineering inequality problem by employing individualized, deficit-designed methods and situating the problem on the students (Peck, 2020), hence keeping the racist system untouched (McGee, 2020; McGee et al., 2021).

Recommendations

Employing the method of not situating the problem on the minority students, challenges the narrative that labels the students who are women or AHN as the problem. More importantly, administrators should design approaches that would help the dominant groups be responsible and accountable for what they say and do (McGee, 2020) and enlighten them on how to be good partners and support women and AHN groups (Moore & Nash, 2021). To further solve this problem, the researchers recommend that universities and program coordinators develop interventions for women, AHN, and dominant groups, including the students and faculty.

These interventions should be structured to recognize microaggression, injustice, and stereotypes and raise awareness. Furthermore, these Intervention programs should help the dominant groups to recognize the effect of what they say, their actions, and their behaviors on women and AHN groups (Blosser, 2020). Although exposing these groups may not directly influence behavior, structural stereotypes, or policy, raising awareness will help the university understand how members of the majority group act toward women and AHN students -this will encourage students to collaborate and network to work on their engineering identity together to increase their confidence in engineering. Finally, engineering faculty and administrators should develop coursework that supports women and AHN students talking about engineering identity, increasing awareness programs on collaboration instead of individualistic values, and promoting a department ruled by a "success together" ideology to foster the persistence of women and AHN (Campbell-Montalvo et al., 2020).

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