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## **Advancing the Engineering Workforce by Enhancing Diversity, Equity, and Inclusion in the Engineering Classroom**

Phoneia Hughes Myers

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ADVANCING THE ENGINEERING WORKFORCE BY ENHANCING DIVERSITY,  
EQUITY, AND INCLUSION IN THE ENGINEERING CLASSROOM

by

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Bachelor of Science in Engineering  
University of South Carolina, 2015

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Submitted in Partial Fulfillment of the Requirements

For the Degree of Master of Science in

Engineering Management

College of Engineering and Computing

University of South Carolina

2023

Accepted by:

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## DEDICATION

It is with great honor that I dedicate this thesis to those who have been influential in my pursuit of education and success. First, I give all honor and glory to God from whom I find strength and determination. Secondly, to the person who inspired me to become an electrical engineer, my father, the late Simon Paul Hughes. With his faith in me, I could achieve any goal I desired. To my mother, Penelope Wright Hughes, who has been a constant source of encouragement throughout my academic career. Finally, to my wonderful husband, Michael Jerrod Myers, who motivates, supports, and prays for me to be successful. Thank you! I could not have accomplished this without you all.

## ACKNOWLEDGEMENTS

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## ABSTRACT

Society's dependence on engineered products is steadily increasing. This dependence requires the engineering workforce to continually innovate and design new advancements. In pursuit of this, engineering employers are implementing diversity, equity, and inclusion initiatives to attract prime candidates and retain employees. For employers to achieve the goals of their initiatives, engineering colleges and universities must produce a diverse pool of graduates. The purpose of this thesis report is to investigate how the diversity, equity, and inclusion concept can be implemented into engineering education to assist with producing diverse graduating classes. A universal methodology is proposed to provide a roadmap on how to implement diverse representation, equitable practices, and an inclusive atmosphere into the administrative and educational structure. The methodology is designed to accomplish two main objectives; aid recruitment efforts to increase enrollment diversity and promote retention of minority engineering students to increase minority graduation rates. In an effort to conduct a feasible and timely research study, a survey-style study was conducted to collect the student point of view on the hypothetical implementation of the proposed methodology. The results of the study are presented as collective, statistical data to reflect the general student perception. At the conclusion of the study, majority of the respondents concur with the diversity and equity elements of the proposed methodology. For the inclusion component of the study, the data reflected that respondents believed the methodology was adequate to support the retention objective, but not the recruitment objective, definitively.

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# CHAPTER 1

## INTRODUCTION

Engineering, a simple word that is complex in practice. It is comprised of utilizing and applying scientific and mathematical concepts to design and create products that largely contribute to the convenience of everyday life including: cell phones, software, bridges, vehicles, medical equipment, automatic teller machines, etc. Engineered products have become an integral component of society. Thus, leading to an increasing societal dependence on those products. As the dependence on engineered products increases, continual innovative advancements in engineering are critical. Innovation requires one to be willing to explore different concepts or view existing concepts from varied perspectives. Varied perspectives are the essence of diversity. Acceptance of diversity is realized when varied perspectives are respected and embraced.

Diversity, equity, and inclusion is a practice that is becoming popular across the workforce. Employers have become more forthcoming when publicly addressing views on acceptance. On job postings, today, it is common to see a statement regarding the hiring company's stance on acceptance, such as language on equal opportunity or inclusive culture. Large corporations, like Microsoft and Amazon, are heavily investing into audits to assess and review the status of diversity and inclusion within their company. Why would multi-billion-dollar companies be interested in and committed to diversity and inclusion? Companies across various industries are also creating and hiring for executive level positions that are devoted to oversee and manage the cultural climate of the company to

ensure the work culture is diverse, equitable, and inclusive. Some companies have gone as far as to donate millions of dollars to minority serving institutions (e.g., Historically Black Colleges and Universities, Hispanic Serving Institutions, etc.) as a way to invest into students from underrepresented backgrounds. Again, this begets the question of why. Why would companies find it valuable to instate a lead to oversee the work culture and invest into minority serving institutions? Aside from the resulting positive public relations, there is clearly organizational value associated with a diverse, equitable, and inclusive workplace environment. The organizational benefits include innovative advancements, increased productivity, and reduced attrition. If there was no operational or financial benefit, companies could, simply, turn a blind eye or exert minimal effort.

The progression towards organizational diversity, equity, and inclusion is, also, present within the engineering workforce. Employers within the engineering industry are seeking to attract top, quality engineers from varied backgrounds. While this is necessary and long overdue, is it statistically possible? To truly realize diversity in the engineering workforce, there must be diversity within and graduating from engineering education. Systematically, once a student graduates, he or she will likely enter the workforce or enroll into graduate school. Therefore, the workforce and education are relatively tied. How can engineering academic institutions be structured to produce diverse graduating classes? I believe that engineering academic institutions can adopt the diversity, equity, and inclusion concept, similar to what is being done in the engineering workforce, to produce the graduates the industry needs. This theory was explored through a research study conducted with engineering students and is presented in this thesis report.

## CHAPTER 2

### BACKGROUND

#### 2.1 DIVERSE CONTRIBUTIONS IN ENGINEERING HISTORY

Throughout history, engineering has been dominated by a specific demographic; white males. The exclusion of specific demographics from institutional engineering academia, historically, has been attributed to educational restrictions placed on women and people of color. During the 19<sup>th</sup> century, several institutions in the United States began establishing formalized engineering degree programs. The first engineering school in the United States was established in 1802 at the U.S. Military Academy at West Point. Others included Rensselaer Polytechnic Institute in 1835, Norwich University in 1834, and Union College in 1845. [14] Notably, the engineering curriculums at these institutions were established prior to the American Civil War and the Women's Suffrage Movement. Therefore, the concept of diversity in these engineering programs was inconceivable. However, pivotal moments in history have allowed those underrepresented groups to break those barriers to revolutionize the engineering academic community and the industry. As a result, history has shown that diversity, particularly racial and/or gender, have served as key contributors to engineering advancement.

Racial diversity has promoted ingenuity in the engineering society despite many harrowing obstacles. During the 19<sup>th</sup> century, the right to an education was not legally protected or prioritized for African Americans. In the Antebellum South, African

Americans were subjected to anti-literacy laws that prohibited enslaved and freed people from the right to an education. These laws also prevented one from attempting to teach African slaves and freedmen how to read and write. The punishment for violating anti-literacy laws could result in a fine and/or imprisonment for those teaching slaves or freedmen. If a slave or freedman was found to be literate, they would suffer brutal, dehumanizing punishments. In the Northern sector of the country, formal educational opportunities were available, but limited. However, this did not impede African Americans from contributing advancements in the arts and sciences. A notable example involves an essential invention that is used without cease, the light bulb. The light bulb, normally credited as an invention of Thomas Edison, had been designed and manufactured by several inventors decades before the Edison incandescent bulb. While many other inventors, before Edison, were successful in creating a filament, vacuum tube style light bulb, generally, the high material costs and low performance for the invention made it impractical for commercial use. After experimenting with different metal filaments, Edison engineered and patented a carbon-filament light bulb with a life span of approximately 13 hours. Various methods were used to manufacture the carbon filament, which normally produced brittle filaments. Lewis Howard Latimer, an African-American inventor and engineer, working for Edison, discovered and patented an improved manufacturing process for the carbon filaments. Latimer's process made the filaments more durable, malleable, and longer-lasting, thus refining Edison's light bulb. [4] This is one of several instances that showcases how diversity contributes to advancement. While Latimer did not invent the light bulb, his technical contributions perfected the design and the manufacturing process.

Latimer's engineered refinements paved the way for practical, commercial use of the light bulb. Ultimately, revolutionizing public society and the electrical engineering industry.

While diversity is present in engineering history, it has not been equitable or openly inclusive. Women, historically, were not viewed as significant contributors within the scientific community. In the United States, societal gender disparities hindered women from leading in academia and the workforce. Prior to and during the 19<sup>th</sup> century, women were mainly subjected and limited to domestic roles of housekeeping, cooking, and/or mothering. Women were largely excluded from higher education until the 1830s. As institutions began accepting female students, opportunities opened for women to study science, technology, engineering, and mathematic (STEM) disciplines. Those who worked in engineering-related fields, normally studied mathematics or one of the physical sciences. In 1876, Elizabeth Bragg became the first woman to earn an engineering degree from an American institution. Bragg received her Bachelor's degree in civil engineering from the University of California, Berkeley. After earning her engineering degree, Bragg worked as an educator before quitting to focus on serving her family as a housewife and mother. [10] After Bragg received her engineering degree, almost half a century passed before a woman was hired to work as an engineer. Early in the 20<sup>th</sup> century, Edith Clarke became the first woman to work as an engineer in the United States. Clarke received her Masters of Science degree in Electrical Engineering from the Massachusetts Institute of Technology (MIT) in 1919. Following her graduation, Clarke worked for General Electric as a computer in the Turbine Engineering Division. While working for General Electric, Clarke submitted a patent for a graphing calculator used to solve electric transmission line calculations. In 1922, Clarke accepted a full-time electrical engineer position at General Electric. [13]

Clarke's engineering work improved the industry's understanding of the electric distribution system and her graphing calculator simplified the complex computations.

In recent years, the contributions of women to the scientific community have become more widely recognized. Katherine Johnson, NASA mathematician, performed pioneering calculations that were essential to the success of several United States' space missions during the Cold War. Johnson performed trajectory analysis for the first United States' human spaceflight, the 1961 Freedom 7 mission. Notably, she is celebrated for hand-calculating orbital equations that controlled the capsule trajectory for John Glen's Friendship 7 mission in 1962. The results of her complex calculations were used in engineering reports and to verify the results of the same equations performed by a computer. The Friendship 7 mission was a success and a pivotal moment in the race to space between the United States and the Soviet Union. However, Johnson's work went unrecognized for decades. Finally, in 2015, Johnson was honored with the Presidential Medal of Freedom from former President Barack Obama. [15] Women have a long-standing history of scientific contributions, including to the engineering field. Undoubtedly, gender diversity plays a critical role in scientific advancement.

## 2.2 WHAT IS DIVERSITY, EQUITY, AND INCLUSION?

"Diversity, Equity, and Inclusion" (DEI) is a trending practice to promote social reform within government and business organizations. It's a holistic concept of acceptance and fairness as characterized by its three interconnected terms. The DEI concept can be implemented into an organization's mission, policies, operating procedures, and/or programs. It promotes unification, belonging, and trust amongst members within a group. These are key aspects that are essential to establishing a strong organization.



Figure 2.1 Diversity, Equity, and Inclusion Comparison [2]

Diversity, in general, is defined as the state of variety or differences. With respect to the DEI concept, it refers to the acknowledgment of the unique characteristics of individuals. Unique features include race, nationality, ethnicity, gender, sexual orientation, disabilities, socioeconomic status, religious beliefs, age, and political affiliation. [16] According to Glassdoor for Employers, approximately 76% of prospective and acting employees agree that a diverse workforce is important when evaluating a company for employment opportunities. [20] Understanding that diversity in the workforce is important, discrimination is a negative factor that can deter diversity. As a counteract, Congress has enacted several anti-discrimination laws to protect employees and job applicants. These laws provide a wide range of protection, including for cultural background, compensation, and health/medical status. Title VII of the Civil Rights Act of 1964 protects against discrimination related to race, color, religion, sex, or national origin. Gender-based wage discrimination for equal work performed in the same organization is prohibited by the Equal Pay Act of 1963. [6] The Pregnancy Discrimination Act protects pregnant women from discrimination in the workplace, including unfair change in employment status, unjustified termination, decrease in pay, exclusion from promotional opportunities, etc. [5]



While discrimination is banned by law, true diversity within an organization is established when everyone's differences are acknowledged, accepted, and embraced.

The second component of the DEI concept is equity. Equity is characterized by impartiality and fairness. It is predicated on diversity, which allows for it to differ from equality. Acceptance of diversity is present when all individuals are treated justly. Considering the DEI concept in an organization, equity is built into the administrative framework through the policies, procedures, and operations of business organizations. Thus, equity plays a vital role in the success of organizations. The Equity Theory of Motivation, created by John Stacey Adams, proposes a direct correlation between the motivation of individuals and fairness. It theorizes that individuals are motivated by fairness when being assessed in comparison to peers. If an individual identifies inequity as compared to peers, the individual will make self-adjustments to establish or reinstate the equity.

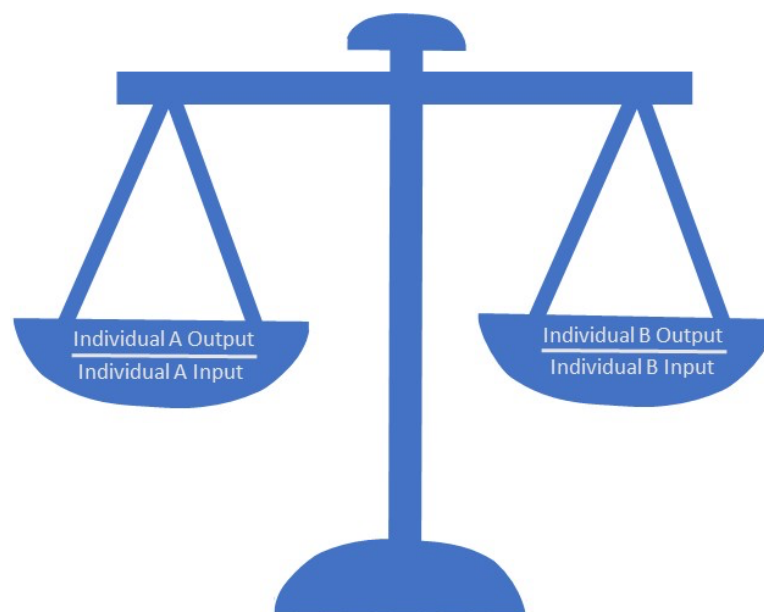


Figure 2.2 Equity Theory of Motivation Model

Based on the theory model, equity is established when an individual's inputs and outputs are equivalent or comparable to another individual's inputs and outputs. For example, if Employee A and Employee B are performing the same tasks (input), the Equity Theory of Motivation is satisfied if both employees receive equal pay (output). However, if Employee B is paid more than Employee A while performing the same tasks, Employee A will adjust their performance (e.g., execute less tasks) to establish equity from their vantage point. [3] From this ideology, one could deduce that equity drives individual motivation, which impacts performance and, subsequently, productivity.

Inclusion is the result of supporting and accepting the diversity of individuals. In the workplace, inclusion is measured by the degree by which diversity is present throughout an organization in decision-making and in promotional opportunities. Inclusion creates a sense of belonging for all individuals in an organization. It creates an environment where individuals' perspectives are heard and valued. This empowers individuals to contribute to the initiatives and goals of the organization. Actively contributing within an organization enhances engagement, which could lead to innovation. When an individual is able to openly give input that is taken seriously, their worth is being recognized. In contrast, when individuals feel underappreciated or disrespected, they are inclined to or desire to leave. Thus, inclusion promotes retention. Reducing attrition has become a priority for all industries across the workforce. In the midst of the COVID-19 pandemic, 47.4 million workers quit their jobs in what is known as "The Great Resignation". [19] A Pew Research Center survey found that 57% of respondents quit their job, in 2021, due to feeling disrespected in the workplace. Only 31% of respondents attribute the coronavirus outbreak as the reasoning for their resignation. [18] Therefore, the correlation between inclusion and

retention is significant. Underappreciation obstructs the sense of belonging and discourages one from actively participating.

### 2.3 BENEFITS OF DEI IN ORGANIZATIONS

Diverse representation, equitable operations, and an inclusive atmosphere benefit both individuals and organizations. From an organizational perspective, implementing the DEI concept fosters a positive environment for everyone to thrive. Positive work environments improve efficiency and retention. Operational efficiency results from the productivity of individuals working within an organization. An organization is defined as a group of individuals working towards a common goal. If one individual feels their contributions are overlooked or unvalued, their performance towards the common goal could degrade, which influences the organizational output. This could also influence the attrition rate within an organization. Turnover and productivity can be improved with organizational DEI. Specific needs of individuals that are critical for efficient human behavior can, also, be satisfied through organizational DEI implementation. Maslow's Hierarchy of Needs theorizes that five fundamental needs regulate human behavior. The hierarchy of these needs are modeled in pyramid form with basic needs starting at the bottom. Each need in ascending order must be fulfilled before reaching the next highest level. The five needs are physiological, safety, belonging (and/or love), esteem, and self-actualization. Figure 2.3 depicts the five fundamental needs in ascending order.



Figure 2.3 Maslow's Hierarchy of Needs Within Organizational DEI

Physiological needs, the first level, describes basic needs for survival, including food, water, shelter, etc. Considering organizational DEI, physiological needs consist of fair policies and procedures for equitable operation of the organization. The second level, safety needs, is defined by protection and security. This could include protection from violence, abuse, or instability. Safety needs are met under organizational DEI when individuals have employment and/or financial security (e.g., paycheck, pension plan, etc.). After physiological and safety needs are met, one must satisfy the need of belonging. Under Maslow's model, belonging needs are correlated with love or social acceptance. Belonging needs are present in organizational DEI when individuals connect with others in an inclusive environment. Next in the hierarchy are esteem needs. These needs are characterized by one's desire for admiration, possibly of oneself and/or by one's peers. Organizational DEI begets respect and recognition achieved from inclusivity. Finally, the highest-level in the hierarchy is self-actualization. This need refers to one realizing their

fullest potential or simply, accomplishment. [17] One's accomplishments could include learning, inventing, winning awards, earning promotions, etc. Organizational DEI encourages self-actualization through the innovation, creativity, and problem-solving that results from a diverse and inclusive organization. Following Maslow's philosophy, organizational DEI can meet the needs of individuals and stimulate human behaviors for increased efficiency and retention.

DEI implementation provides social benefits by presenting organizations as progressive institutions. Companies can appeal favorably to the public with diverse personnel that can connect and empathize with various cultural and socio-economic communities. It begets a competitive advantage by improving market appeal that assist with attracting diverse talent. All companies seek to hire bright, diligent, and skilled applicants. Commonly, companies attempt to attract quality applicants through competitive compensation, benefits packages, and personal time off. These benefits are essential factors for applicants to consider when selecting new employment. However, these tangible elements are limited. In order for businesses to maintain financial stability and reach profitability, operating expenses (e.g., compensation, benefits, etc.) must be controlled. Organizations can further appeal to quality talent and differentiate from competitors through intangible benefits resulting from DEI implementation. Diverse representation, equitable treatment, and inclusive environments are intangible benefits of high value with manageable financial costs.

## CHAPTER 3

### RESEARCH REVIEW

#### 3.1 THE GREAT RESIGNATION

Emerging from the economic impacts of the COVID-19 pandemic, the United States workforce is in the midst of a “Great Resignation”. Employees, in record numbers, are voluntarily resigning from their jobs. Following the Great Recession (2007-2009), the unemployment rate in the United States reached a high of 10.0%. The unemployment rate fell gradually to 3.5% before the start of the pandemic. According to the U.S. Bureau of Labor Statistics, by April 2020, the unemployment rate reached a staggering 14.7%. By February 2020, the unemployment rate gradually fell to 3.8%. While the unemployment rate has improved, the resignation rate is on the rise. Prior to the pandemic, the quit rate, generally, did not exceed 2.4%. By November 2021, the quit rate reached a record 3.0% and remains elevated above pre-pandemic resignations rates [Figure 3.1]. [11]

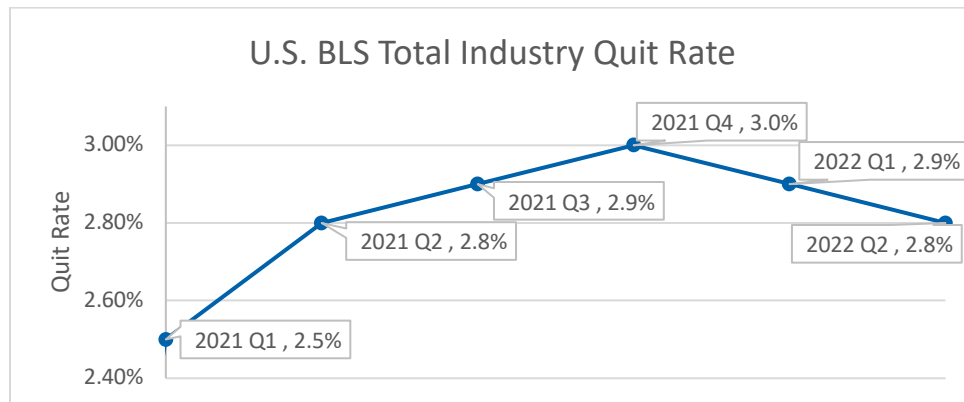


Figure 3.1 U.S. Bureau of Labor Statistics Quit Rate Graph [8]

According to the U.S. Bureau of Labor Statistics, in 2021, approximately 47.4 million employees resigned from their employment. With the excessive industry turnover, several businesses are in the midst of hiring. The shift in the U.S. labor market presents a unique opportunity for companies to reevaluate business practices and the work environment. From an engineering standpoint, the Great Resignation presents a prime opportunity for companies to hire a diverse pool of engineers and retain them with the assistance of equitable practices and an inclusive atmosphere.

### 3.2 DIVERSITY IN THE ENGINEERING WORKFORCE

The engineering workforce is significantly lacking in diversity across industries. Unfortunately, this deficiency in diversity has sustained throughout the centuries-long history of the profession. To negate the current unprecedented instability of the labor market, this section will present 2019 workforce data. The total impact of the COVID-19 pandemic and the Great Resignation on the overall workforce is not fully realized as the labor market and society continue to adjust to the public health crisis.

Prior to the Great Resignation, the engineering workforce notably lacked diversity of race and gender. In 2019, the National Science Foundation (NSF) reported that 84% of engineering occupations were employed by males and 16% by females. The racial representation within both genders further highlights the workforce inequalities. Employees who identify as White represent more than 60% of both gender demographic groups. Following are Asian employees with 21% male representation and 17% female representation. All other races represent 10% or less of each gender demographic group.

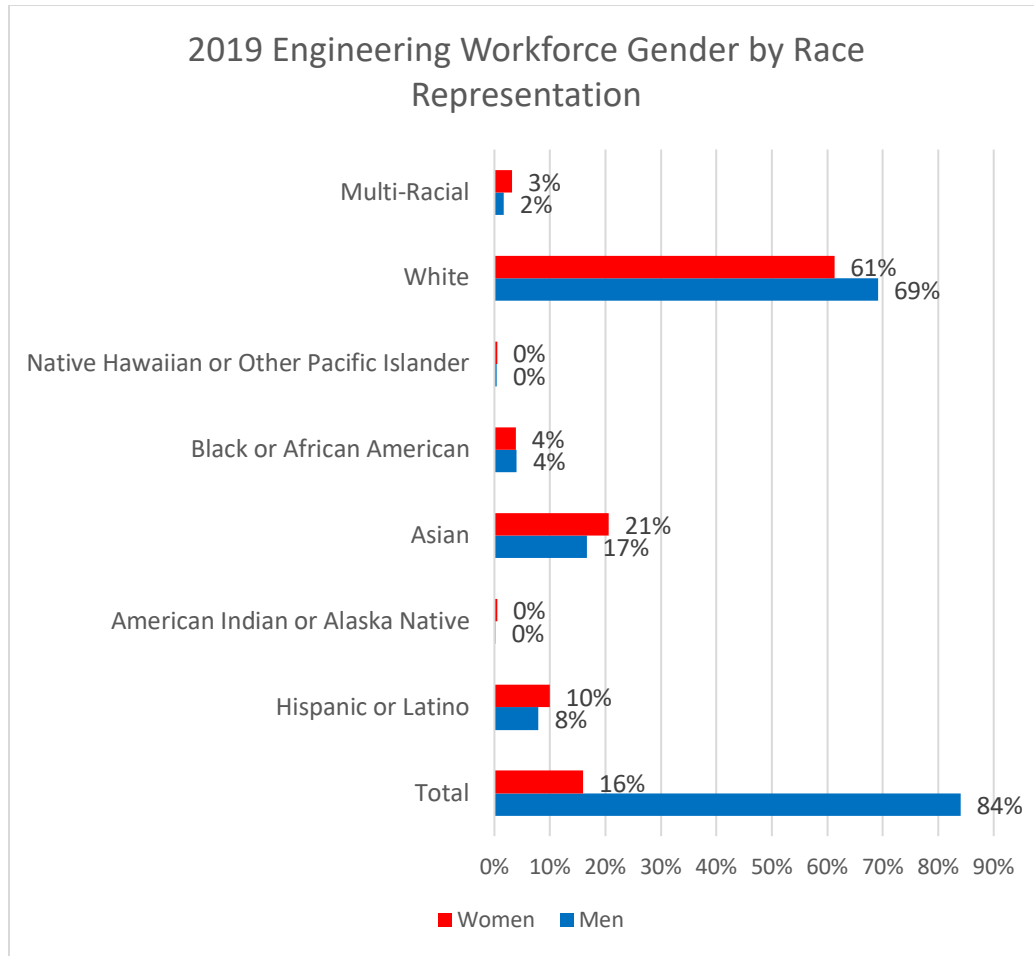


Figure 3.2 2019 Engineering Workforce Representation of Gender by Race [12]

Independent of gender, the 2019 NSF report indicated the following race percentages for engineering occupations: 68% White, 17% Asian, 8% Hispanic or Latino, 4% Black or African-American, and 2% Multi-Racial. [12] Native Hawaiian or Other Pacific Islander and American Indian or Alaska Natives are severely underrepresented. Native Hawaiians or Other Pacific Islanders represent only 0.2% of all science and engineering occupations. [7] Similarly, American Indian or Alaska Native employees represent 0.3% of engineering occupations and only 0.1% of engineering faculty. [9]



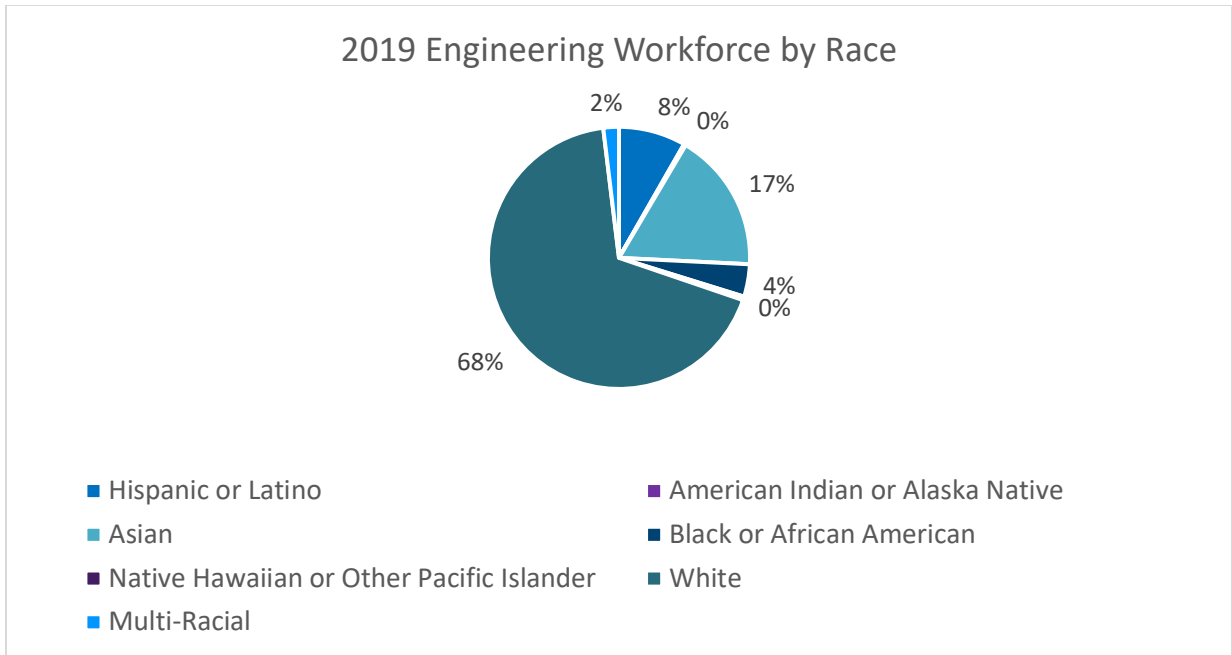


Figure 3.3 2019 Engineering Workforce Representation of Race [12]

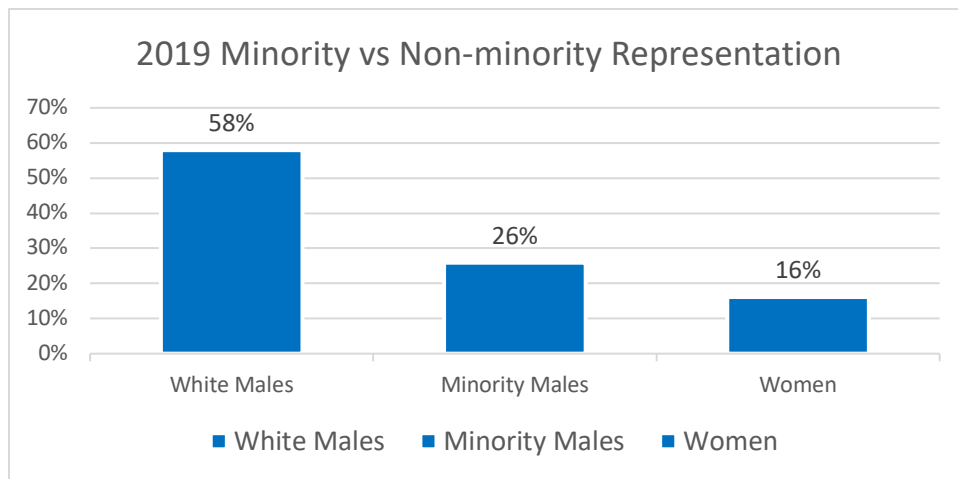


Figure 3.4 2019 Engineering Workforce of Minority and Non-minority [12]

In total, minorities by race and gender only constitute about 32% of employed engineering occupations. White males dominate the engineering workforce by 58%.

### 3.3 DIVERSITY IN ENGINEERING ACADEMIC INSTITUTIONS

Two hundred and twenty years after the first engineering college in the United States was commissioned at the Military College at West Point, diversity in engineering education enrollment and graduation is remarkably low. The engineering employment minority distribution reflects how the representation in engineering classrooms is relative to the representation in the workforce. This section will present statistics reflective of minority distributions of undergraduate enrollment in and graduation from engineering programs at academic institutions. This data supports the methodology to improve upon enrollment and retention efforts to increase the minority representation in the engineering workforce. Graduate level enrollment and graduation data is not presented because it is reasonably assumed that most graduate students are represented in the engineering field in either industry or higher education.

The minority distribution of engineering undergraduate enrollment resembles the minority distribution of engineering employees. In 2020, the American Society for Engineering Education (ASEE) reported that 75.8% of the undergraduate engineering enrollment was male and 24.2% was female. There is a 51.6% difference between male and female enrollment [Figure 3.5].

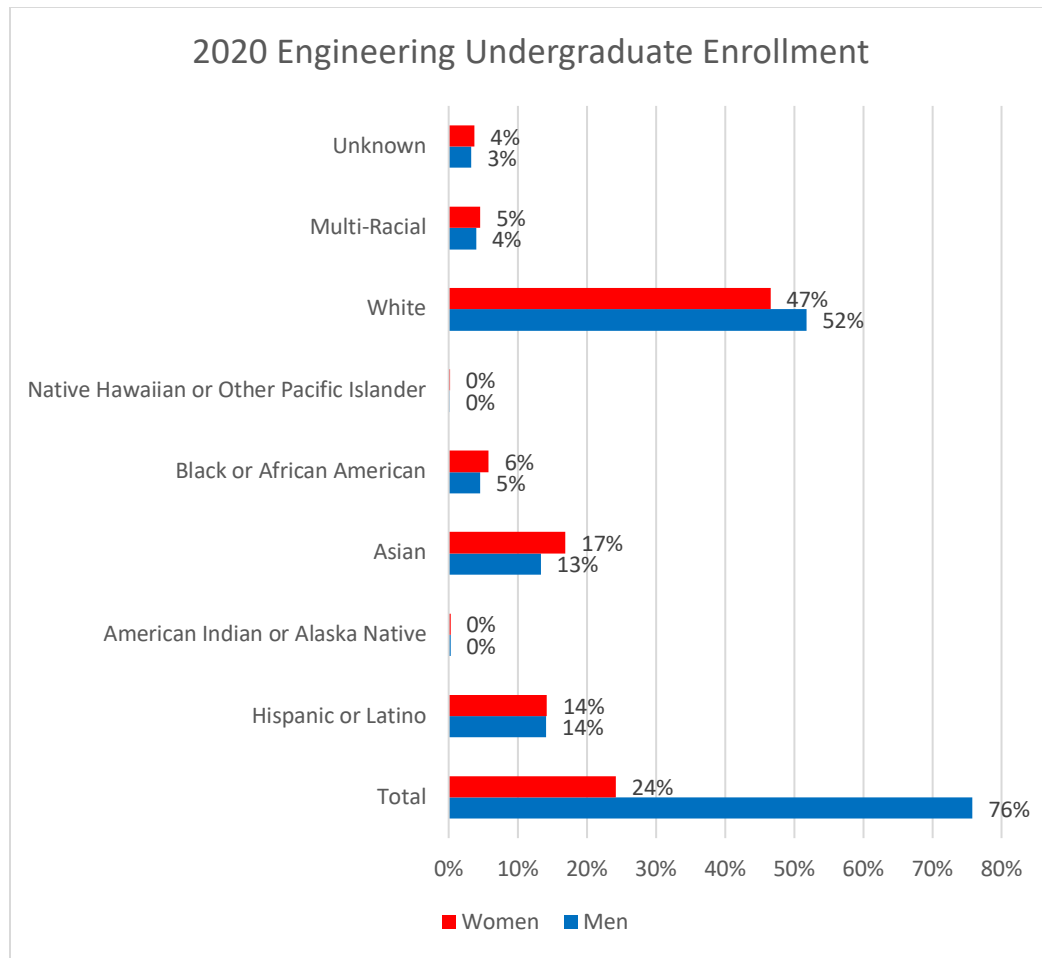


Figure 3.5 2020 Engineering Undergraduate Enrollment by Race and Gender [1]

The ASEE, also, reported the following racial distribution for engineering undergraduate enrollment: 54.6% White, 15.5% Asian, 15.5% Hispanic or Latino, 5.4% Black or African-American, 5.2% Other, and 3.8% Unknown. [1] As shown in Figure 3.6, students that identify as White, constitute more than 50% of the undergraduate enrollment population.

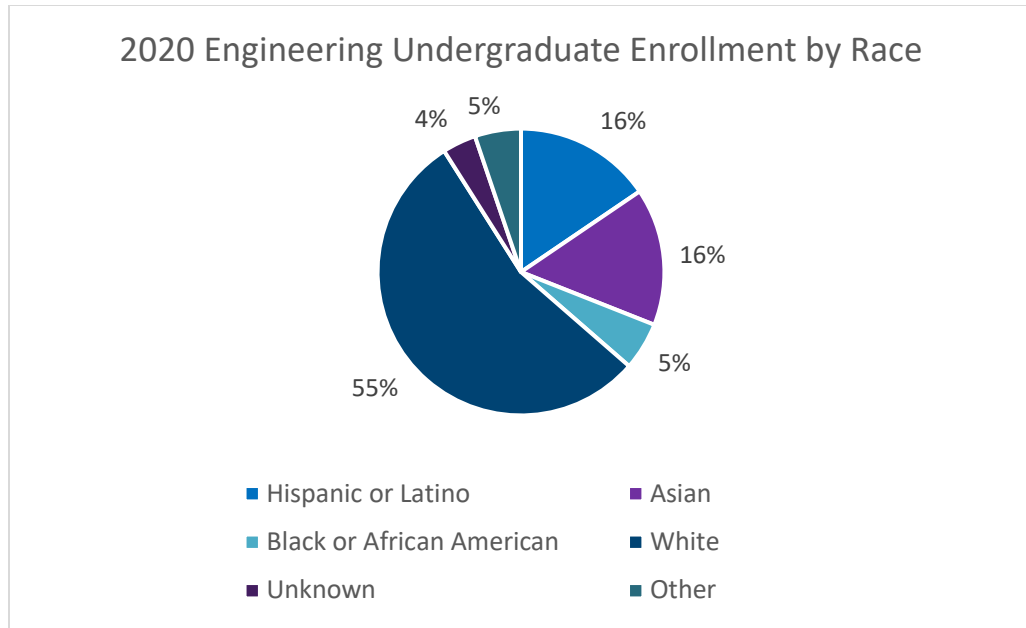


Figure 3.6 2020 Engineering Undergraduate Enrollment by Race [1]

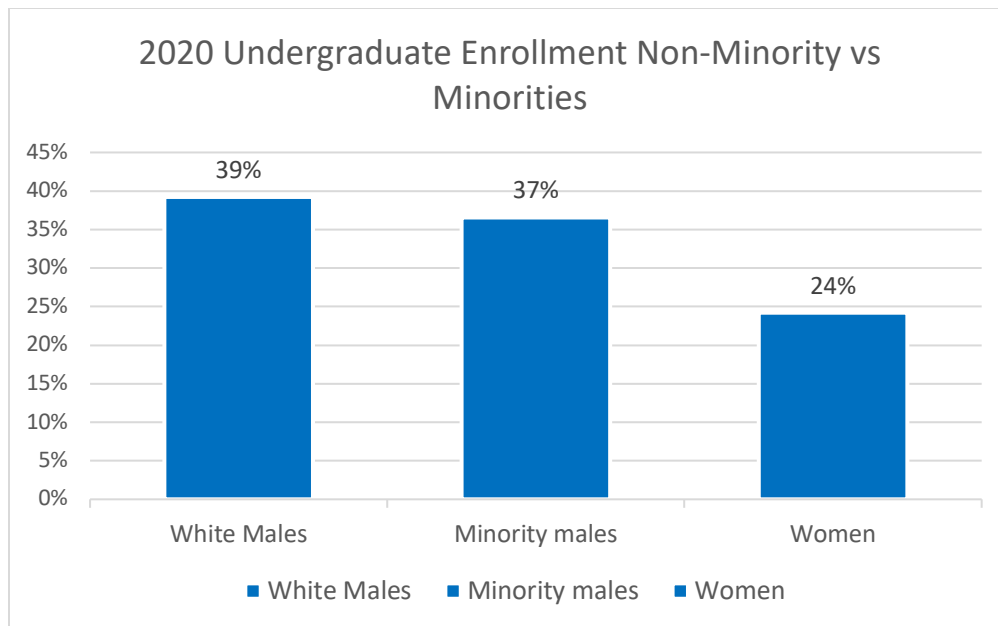


Figure 3.7 Undergraduate Enrollment Non-Minority vs Minorities [1]

Overall, the 2020 engineering undergraduate enrollment is dominated by one specific demographic group, white males. Represented in Figure 3.7, the white male population

exceeds the total population of minority males and, separately, the total population of women. Thus, recruitment efforts to balance the gender and race enrollment in engineering education is a valid need.

Following the undergraduate enrollment data, the engineering Bachelor's degree data will be presented to assess minority distributions with respect to retention and graduation.

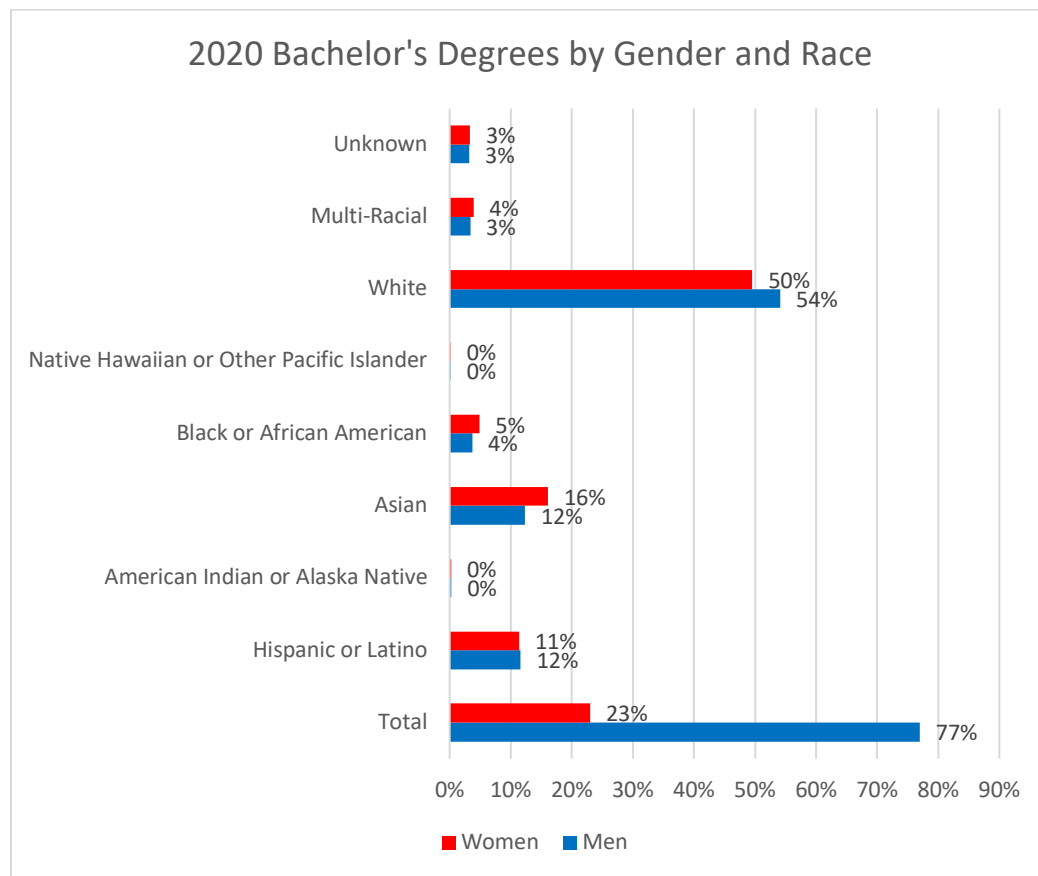


Figure 3.8 2020 Engineering Bachelor's Degrees by Gender and Race [1]

As shown in Figure 3.8, the Bachelor's degrees awarded by gender and race almost mirrors the undergraduate enrollment. However, there is a notable distinction. Considering race, there is a decrease in graduations for all races with percentages above 0%, except for graduates that identify as White. There is a 3% increase for white women and a 2% increase

for white men. The racial minority representation percentage is lower at graduation as compared to enrollment percentages. In 2020, white graduates amounted to approximately 60% of all graduates, Figure 3.9, who earned an engineering Bachelor's degree. Referencing gender, there is a 1% increase in males graduating and 1% decrease in female graduates as compared to enrollment percentages. In 2020, males, also, exceeded females in graduation by 54%. Over three quarters of engineering Bachelor's degrees were awarded to males. The decrease in percentages, whether by race or gender, primarily resides within the minority groups. This strongly suggests there is room for improvement regarding retention.

Overall, in 2020, the percentage of white male graduates with Bachelor's degrees outnumbered all other demographic groups. Figure 3.10 shows that the percentage of female graduates is well below both non-minority (19% less) and minority males (12% less). Minority males are outnumbered by non-minority males by 7%. As compared to enrollment in Figure 3.7, there is a lower representation of minority male (2% less) and female (1% less) graduates.

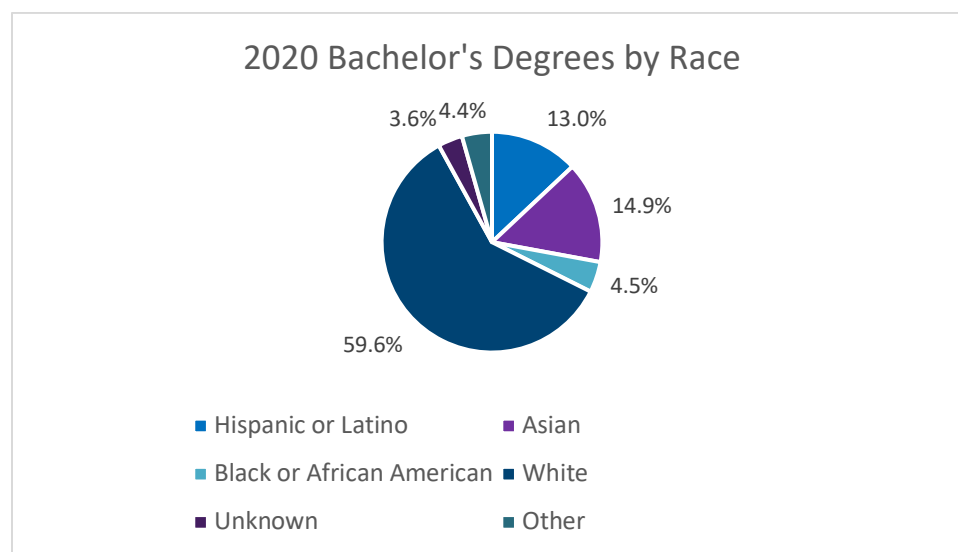


Figure 3.9 2020 Bachelor's Degrees Awarded by Race [1]

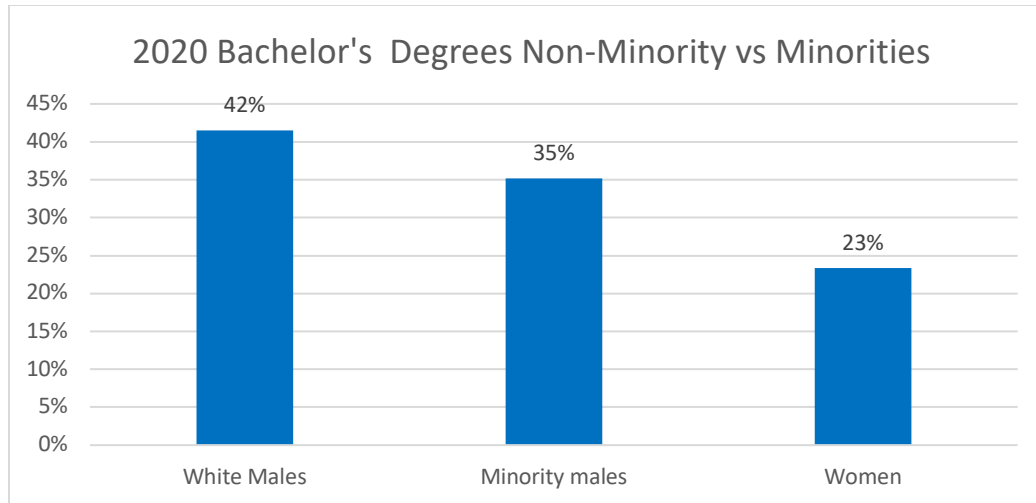


Figure 3.10 2020 Minority Distribution of Engineering Bachelor's Degrees [1]

Low representation of gender and race diversity in engineering graduation is not an isolated coincidence that occurred in 2020. For the last decade, the ASEE has reported significant disparities in minority graduation percentages for gender and race. Figure 3.11 shows a staggering 54% - 64% difference between the graduating percentages of men versus women. Within this ten-year span, over 75% of engineering Bachelor's degrees were awarded to men. This is significant considering that women have earned less than 25% of degrees awarded each year for a decade or more. While there is an inward trend for the gender lines, there is a substantial need for efforts to balance the gender representation.

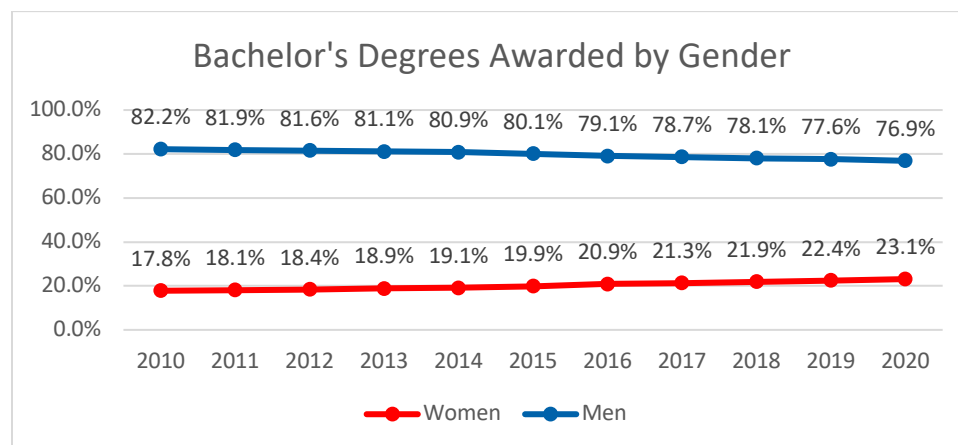


Figure 3.11 Ten-year Timeline of Bachelor's Degrees Awarded by Gender [1]

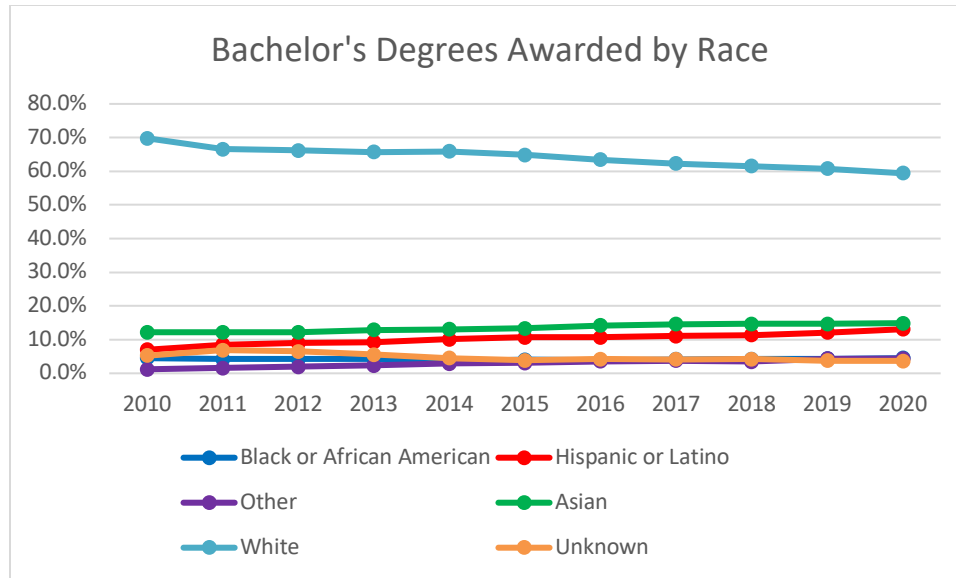


Figure 3.12 Ten-year Timeline of Bachelor's Degrees Awarded by Race [1]

Similarly, the Bachelor's degrees awarded by race reflect large disparities. Graduates that identify as White amount to at least 60% of all engineering Bachelor's degrees awarded each year for the last decade. Furthermore, all of the racial minority groups, individually, represent less than 20% of degrees earned each year. Over the ten-year span, there has been at least a 45% difference between non-minority and minority graduates.



## CHAPTER 4

### METHODOLOGY & EXPERIMENT

#### 4.1 PROPOSED METHODOLOGY

Based on the data presented in Chapter 3, the racial and gender representation is lacking in the engineering workforce and education. The data shows a correlation between the minority distribution of the engineering workforce and academic institutions. The non-minority demographics (i.e., white and/or male demographics) represent more than 50% of the engineering workforce, undergraduate enrollment, and Bachelor's degrees awarded. This is also reflected in the ten-year history of Bachelor's degrees awarded from 2010 to 2020. Thus, leads to the question; how can DEI truly be championed in the engineering workforce if it is not realized in engineering education? To improve the disparities, I propose that engineering academic institutions implement initiatives that promote the DEI concept into the administrative and educational frameworks similar to the initiatives that are instated in business organizations.

The concept of diversity, equity, and inclusion has been implemented into business organizations to promote advancement, reduce attrition, and improve the work environment. Similarly, the DEI concept can be implemented into academic institutions to accomplish comparable goals. Incorporating the DEI concept into engineering academic institutions can accomplish two key objectives; aid recruitment efforts to increase enrollment diversity and promote retention of minority engineering students to increase minority graduation rates. A strategic methodology centralizing the DEI concept can be

adopted as a roadmap for all engineering colleges and universities. The implementation will vary based upon the needs and available resources of each individual institution. This section will outline the proposed strategic methodology.

As outlined in Chapter 2, DEI is a holistic concept that seeks to level the playing field for all individuals. Diversity highlights the representation of people and perspectives. In the academic setting, diversity should be present amongst the faculty and the students. Equity, as defined by fairness and impartiality in policy and practice, should be present within the administrative structure of the institution and access to resources. Inclusion defines the sense of belonging for all members within an organization. This is realized in academic institutions through visibility, awareness, training, and outlets for expression. In Table 4.1, I propose the following methods be implemented into engineering academic institutions to achieve the DEI concept.

The proposed methodology is geared towards achieving the two main areas of interest; recruitment and retention. Diversifying the faculty and student body through strategic recruitment efforts aim to accomplish the Diversity component of the methodology. The overall methodology for equity promotes recruitment and retention efforts for minority students. Establishing a DEI initiative to accomplish defined objectives provides the foundation to build equitable practices into engineering colleges. Providing access to financial resources for students from underprivileged or underrepresented backgrounds levels the financial playing field. Students who do not have the adequate financial support from home to attend school will likely have to work to support themselves, instead of primarily focusing on their studies. Students who are unable to prioritize their schoolwork are more likely to leave or be removed from their academic

programs. Thus, providing access to financial resources assists with retention efforts. For inclusion, establishing DEI visibility is useful for recruitment and retention efforts. It is important for students, faculty, and the community to know about how colleges and universities are practicing DEI. Employers could, also, consider an institution's DEI efforts to be attractive and may prioritize recruiting the institution's graduates. The remaining elements for the inclusion methodology are steered towards the retention objective. Gaining/maintaining awareness of the faculty and student experience within an engineering college, utilizing faculty and student feedback to optimize DEI initiatives, providing education on the DEI concept, and initiating a social assistance program for students are methods to cultivate or heighten a culture of belonging and to provide an avenue to receive valued feedback.

While Table 4.1 delineates the methodology as individual strategies for each component of the DEI concept, the strategies are interdependent like the DEI components, as shown in Figure 4.1. For example, efforts to diversify the study body can be supported by providing access to financial resources for underprivileged or underrepresented backgrounds. Establishing a DEI initiative with defined goals creates an avenue for faculty and students to share about their experience within the engineering institution. Providing DEI training for students and faculty educates them on how to champion the DEI initiatives that are in place.

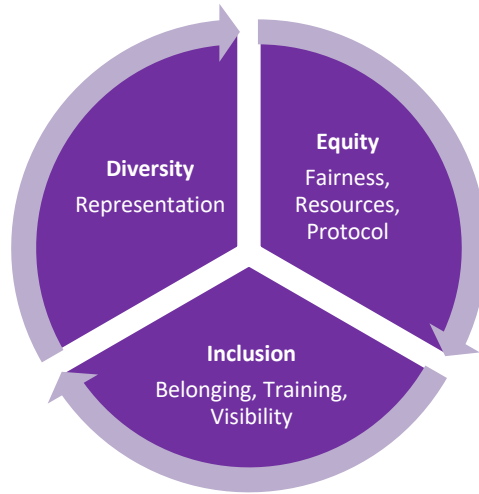


Figure 4.1 DEI Strategic Methodology Model

## 4.2 EXPERIMENT DESCRIPTION

Testing the proposed methodology could have taken several forms. Physical testing of the methodology through implementation would require several levels of approval from senior faculty members at an engineering institution and years of oversight to evaluate the full impact. In the interest of executing a feasible research study in a concise timeframe, the experiment was developed to gain the insight on the student perception of the proposed methodology. The student point of view was the most desirable and provides valuable data because students are, ultimately, the primary benefactor of the two objectives of the methodology. Thus, the research study was conducted in a survey-style format.

Prior to executing the research study at the University of South Carolina, the appropriate approvals were acquired first. For all research studies that request the involvement of human subjects, the University requires the study to be submitted and approved by the Office of Research Compliance Institutional Review Board. The submission process begins with the six-hour Human Subjects Training. My thesis advisor

and I were required to complete the training and pass the examinations. Upon completion of the training, I submitted my research study application which included the study description, objectives, and materials. Review and approval from the Institutional Review Board is essential to ensure that research studies conducted at the University do not violate legally protected rights of the prospective human subjects. Following the approval, I contacted several engineering professors to request a twenty-minute classroom visit to conduct my research study. Fortunately, I was afforded the opportunity to visit four class sessions across various engineering disciplines.

During the classroom visits, the research study began with a brief presentation to the engineering students about my thesis topic. The presentation included a definition of the DEI concept, statistical data of the minority representation in the engineering workforce and education, and the proposed methodology. The presentation was followed by the survey to collect the student Perception on the possible incorporation of the DEI concept into engineering education. The survey was conducted electronically and included demographic questions and questions regarding the DEI concept with respect to the proposed methodology [Appendix A]. Participation in the survey was strictly voluntary and did not impact the students academically. The survey data was collected anonymously and is presented collectively as statistical data, as shown in Chapter 5. No personal identifying information was collected with the study results; thus, survey responses cannot be traced to individual respondents.

Table 4.1 Proposed DEI Methodology Matrix

Component	Proposed Methodology	Examples of Implementation
<b>Diversity</b> <i>Representation</i>	<ul style="list-style-type: none"> <li>• Diversify the faculty.</li> <li>• Diversify the student body.</li> </ul>	<ul style="list-style-type: none"> <li>• Periodic review of the racial and gender representation in the faculty and student body.</li> <li>• Exercise hiring tactics to pursue professors of diverse backgrounds.</li> <li>• Implement efforts to recruit diverse prospective students enrolled in secondary education.</li> </ul>
<b>Equity</b> <i>Fairness</i>	<ul style="list-style-type: none"> <li>• Establish a DEI initiative to accomplish defined objectives.</li> <li>• Financial resources for underprivileged or underrepresented backgrounds.</li> </ul>	<ul style="list-style-type: none"> <li>• Implement strategic plan with measurable goals.</li> <li>• Establish a committee or lead to oversee and manage the strategic plan implementation and performance.</li> <li>• Establish, inform, or provide access to scholarships, work study, or grants for underprivileged or underrepresented demographics.</li> </ul>
<b>Inclusion</b> <i>Belonging</i>	<ul style="list-style-type: none"> <li>• Gain or maintain awareness of faculty and student experience within the engineering institution.</li> <li>• Utilize faculty and student feedback to optimize DEI initiatives.</li> <li>• Provide education on the DEI concept, its importance, and applicable initiatives.</li> <li>• Establish DEI visibility.</li> <li>• Initiate a program for students to receive academic and/or social assistance.</li> </ul>	<ul style="list-style-type: none"> <li>• Issue periodic climate survey to collect the student and faculty experience.</li> <li>• DEI training for students and faculty.</li> <li>• Cultural holiday recognition, highlight minority professional clubs, DEI initiative posted on the institution's website, etc.</li> <li>• Mentorship program for all students.</li> </ul>

## CHAPTER 5

### RESULTS & DISCUSSION

The research study, overall, was conducted at The University of South Carolina's College of Engineering and Computing. The engineering classroom visits resulted in a total of seventy-seven (77) students voluntarily participating in the research study. The results are compiled as collective, statistical data to present the general student perception on the proposed methodology. The results do not reflect the students' actual understanding or experience of the proposed methodology. Following the presentation, the survey began with five demographic questions [Appendix A]. The demographic questions provide insight on the survey respondents' background and potential justification behind the results of DEI questions.

What is your race?

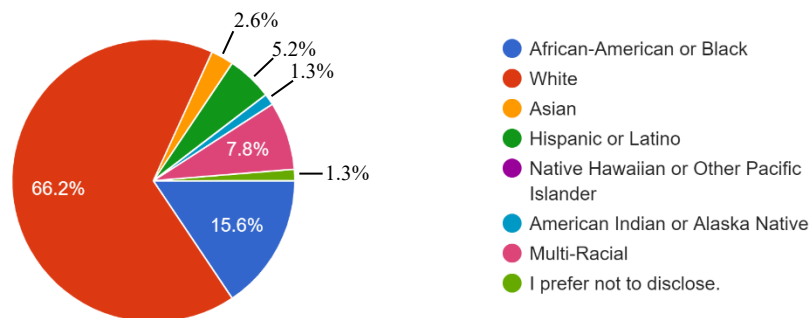


Figure 5.1 Racial Representation of the Survey Respondents

What gender do you identify with?

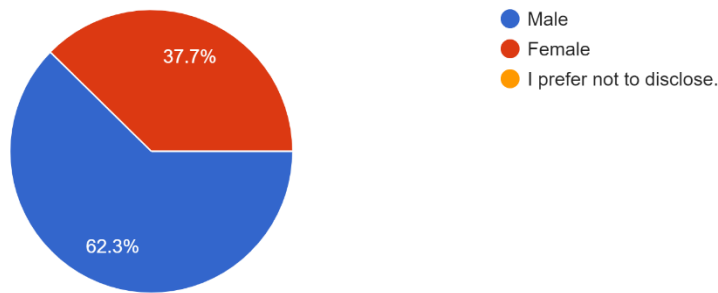


Figure 5.2 Gender Representation of the Survey Respondents

As shown in Figures 5.1 and 5.2, majority of survey respondents identified as white and/or male. Thus, resulting in over 30% of respondents identifying with a minority group and/or female. This percentage is slightly above the ASEE national averages presented in Figure 3.5 and directly aligns with Figure 5.3.

Which do you identify as?

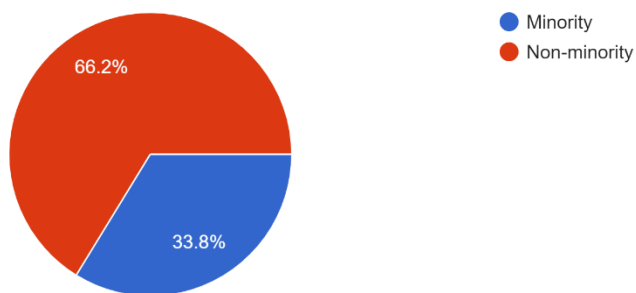


Figure 5.3 Minority/Non-minority Representation of the Survey Respondents



What level of education are you currently enrolled as?

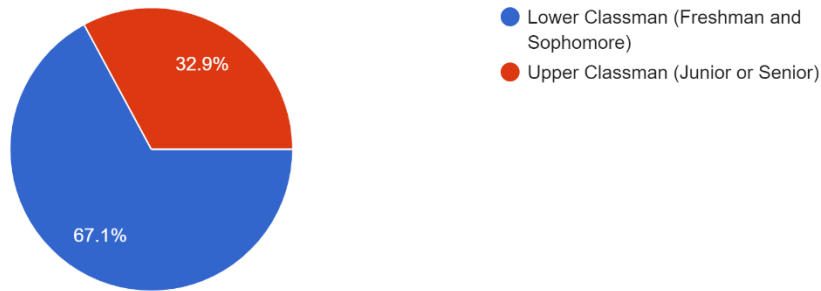


Figure 5.4 Education Status of the Survey Respondents

The survey respondents, also, represent a mixture of educational levels, including lower and upper classman, Figure 5.4. The diversity in education status is valuable because it shows that the survey data contains the perception of newly enrolled students and students preparing to enter the workforce.

Which economic level best represents your background prior to enrolling into college?

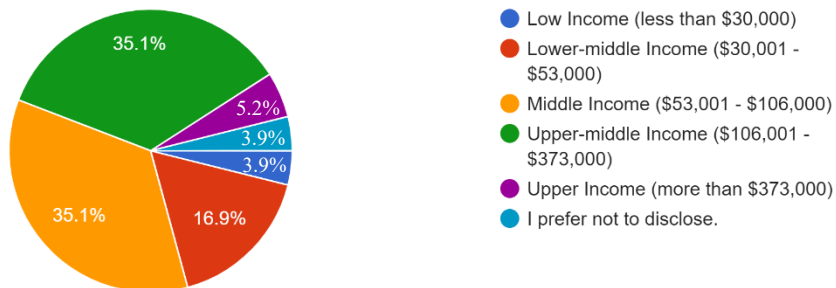


Figure 5.5 Economic Background Representation of the Survey Respondents

The economic representation of the survey respondents is fairly inequivalent if evaluated in terms of high income and moderate-low income. As shown in Figure 5.5, 40.3% of the respondents have backgrounds with high economic resources of the upper-middle and upper classes. Additionally, 55.9% of respondents classify their background economic

resources within the moderate-low income range, including middle, lower-middle, and low classes.

Following the demographic questions, the survey presented eighteen (18) questions related to the respondents understanding and perception of the DEI concept and the proposed methodology given during the presentation. The second half of questions seek to independently obtain the respondents viewpoint prior to the presentation and their viewpoint after the presentation.

Prior to today's presentation, how important was diversity to you?

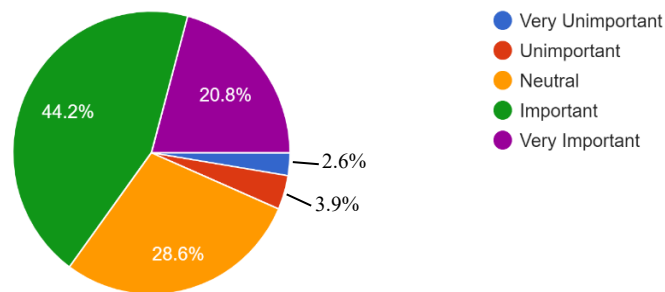


Figure 5.6 Perception on Diversity Prior to Research Presentation

Prior to today's presentation, how important was equity to you?

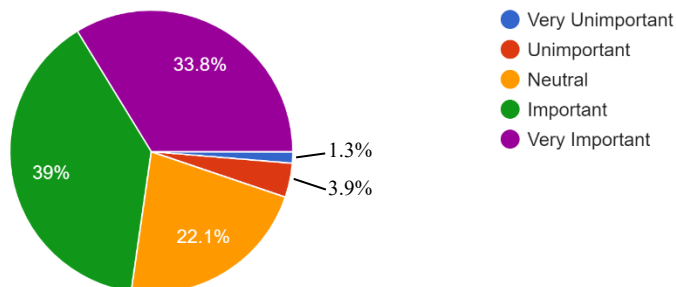


Figure 5.7 Perception on Equity Prior to Research Presentation

Prior to today's presentation, how important was inclusion to you?

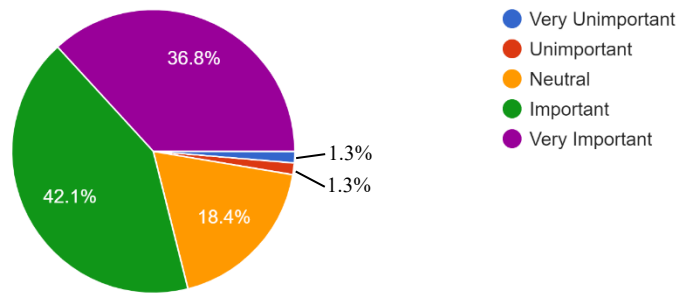


Figure 5.8 Perception on Inclusion Prior to Research Presentation

Prior to the presentation, majority of the students felt that DEI, in general, was an important concept to them with 65.0% for diversity [Figure 5.6], 72.8% for equity [Figure 5.7], and 78.9% for inclusion [Figure 5.8]. However, only 54.6% felt that they had at least a high understanding of the DEI concept [Figure 5.9] prior to the presentation. To strengthen the general understanding and execution of the DEI concept, it is critical for the student body to receive clear guidance or training on the concept, as proposed in the methodology.

Prior to today's presentation, how would you rate your level of understanding of the Diversity, Equity, and Inclusion (DEI) concept?

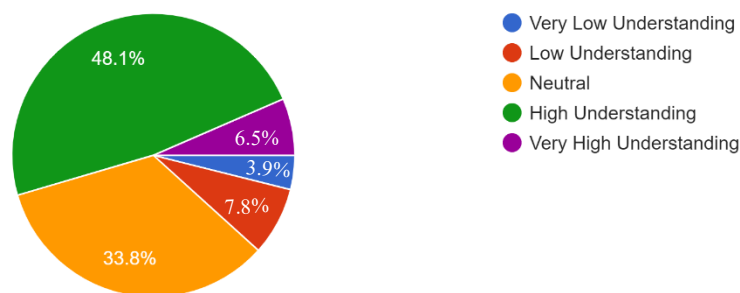


Figure 5.9 Understanding of the DEI Concept Prior to Research Presentation

Notably, over 89% of the respondents were aware of the racial and gender disparities within the engineering academic community [Figure 5.10] and workforce [Figure 5.11]. This high-level of awareness could be interpreted as the reasoning as to why the majority of the respondents, collectively, feel that DEI is important to them. While the respondents possess the necessary awareness and vested interest towards the concept, there is not the same level of understanding about the concept, which can hinder execution.

Prior to today's presentation, were you aware of the racial and gender disparities within the engineering academic community?

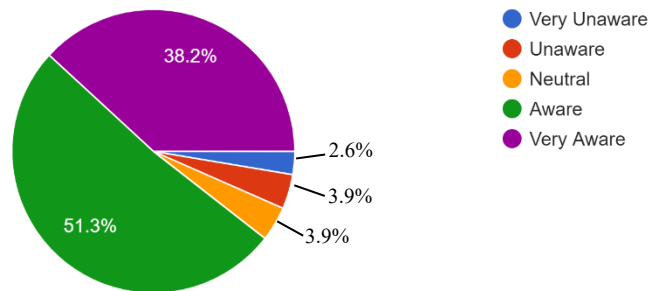


Figure 5.10 Awareness of the Racial and Gender Disparities in Engineering Education

Prior to today's presentation, were you aware of the racial and gender disparities within the engineering workforce?

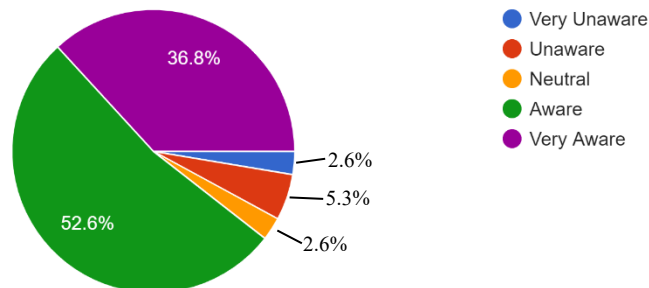


Figure 5.11 Awareness of Minority Disparities in the Engineering Workforce

Following the research presentation, the respondents reported an overall increase in their level of understanding of the DEI concept as compared to prior to the presentation. Figure 5.12 shows that 77.9% of the respondents feel that they have either a high or very high understanding of DEI. This percentage is 23.3% higher than the results shown in Figure 5.9. This is a substantial increase. Considering that the content of the presentation included clear guidance on the DEI concept and its overall importance to an organization, respondents were able to absorb the information, which garnered positive results towards their overall perception of DEI. Consequently, this supports the DEI training component of the proposed methodology. Similarly, Figure 5.13 reports that 83.2% of respondents feel that diverse representation, equitable practices, and an inclusive environment is either important or very important for engineering colleges. This is an increase above the respondents' general level of interest towards DEI prior to the presentation.

After today's presentation, how would you rate your level of understanding of the DEI concept?

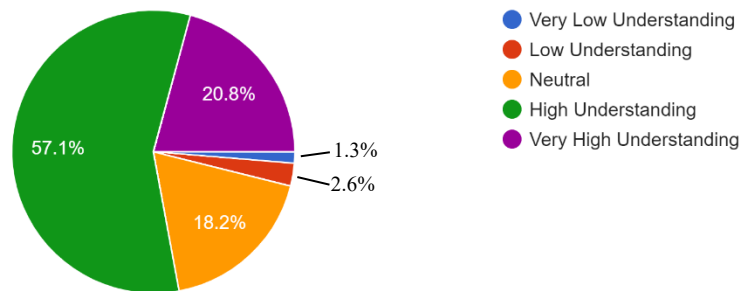


Figure 5.12 Understanding of the DEI Concept After the Research Presentation

Following the presentation, do you feel that it is important for engineering colleges to have a diverse representation, equitable practices, and an inclusive environment?

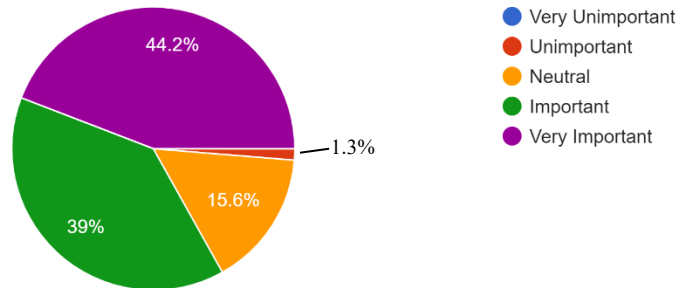


Figure 5.13 Perception on DEI Incorporated into Engineering Colleges

To assess the Diversity component of the proposed methodology, the survey participants were requested to provide their perception towards a diverse faculty and student body. Figures 5.14 and 5.15 exhibit the respondents' appreciation for a diverse faculty and student body, respectively. Over 70% of respondents answered 'Yes', affirmatively. The 21.3% - 26.3% that answered 'Maybe' are likely unsure about a diverse faculty and/or student body because they've never experienced either. However, that particular group might be willing to experience a diverse faculty and student body in order to obtain an affirmative position. Most notably, only 1.3% of respondents, definitively, are not interested in learning from a diverse faculty, nor interested in learning with a diverse student body. While that is a disappointing response, it does not undermine the diversity component of the proposed methodology.

Would you appreciate learning from a diverse faculty?

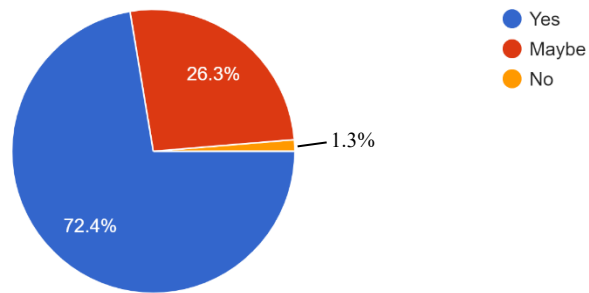


Figure 5.14 Perception on a Diverse Faculty in Engineering Colleges

Would you appreciate learning with a diverse student body?

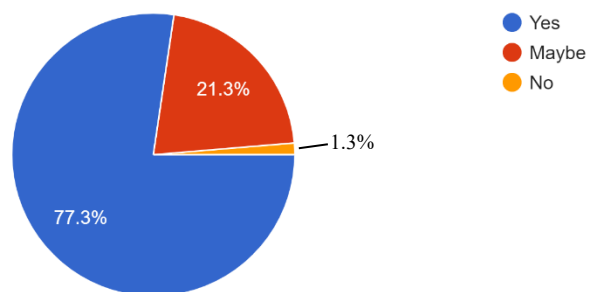


Figure 5.15 Perception on a Diverse Student Body in Engineering Colleges

The next sub-set of survey questions evaluated the Equity component of the proposed methodology. The Equity component sought to achieve fairness by proposing the establishment of a DEI initiative to accomplish defined goals and access to financial resources for underprivileged or underrepresented backgrounds. With respect to establishing and implementing a strategic plan, 57.3% of respondents are in favor and 36% of respondents are open to it [Figure 5.16]. Thus, 93.3% of respondents are at least potentially receptive to a DEI strategic plan for engineering colleges. As shown in Figure

5.17, 52% of respondents would feel secure having a committee or lead to oversee the DEI climate at an engineering college. The responsibilities of the committee or lead could include overseeing the DEI strategic plan and initiatives.

Would you appreciate if the engineering college established and implemented a strategic action plan with clear goals and measurable outcomes to incorporate the DEI concept?

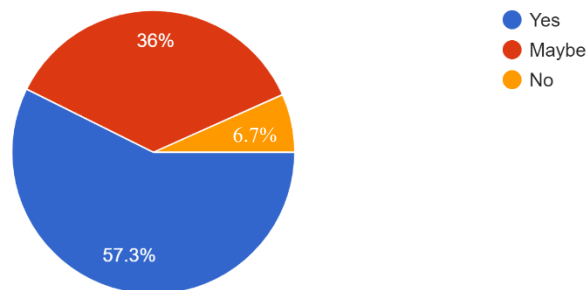


Figure 5.16 Perception on a DEI Strategic Plan for Engineering Colleges

Would you feel secure if a committee or lead was in place to oversee the DEI climate at the engineering college?

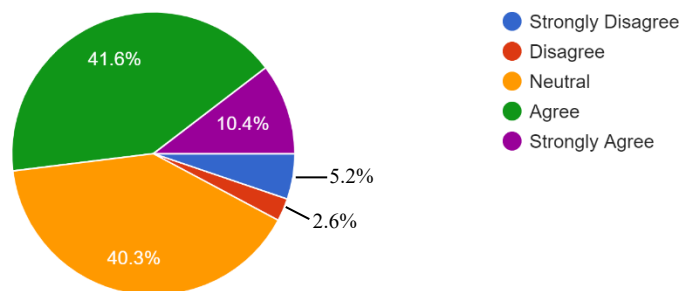


Figure 5.17 Perception on a DEI Lead/Committee for Engineering Colleges

Lastly, over 69% of respondents voted in favor of providing access to financial resources for disadvantaged or underrepresented students [Figure 5.18]. Interestingly, this response exceeds the 55.9% of respondents who identify with moderate-low economic backgrounds.



Thus, suggesting that students from advantaged and/or frequently represented backgrounds, also, see the value in economic equity. One would expect for the respondents of moderate-low economic means to support specific access to financial assistance because their demographic would benefit. For students from more affluent backgrounds to support financial equity is profound.

Do you feel it would be beneficial if the engineering college provided or partnered with a third-party organization to provide financial assistance to students from unprivileged or underrepresented backgrounds?

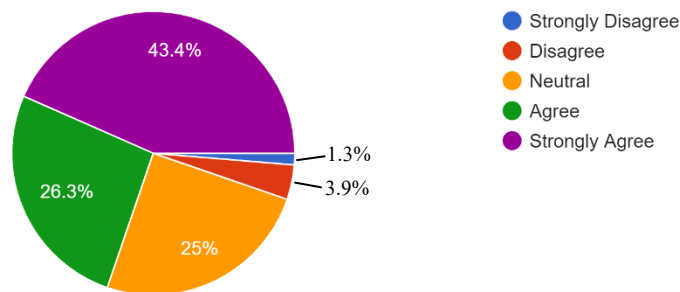


Figure 5.18 Perception on Access to Financial Resources

The final sub-set of survey questions pertained to the Inclusion component of the proposed methodology. The Inclusion component includes methods geared towards gaining and/or maintaining awareness of the faculty and student experience within an engineering college, establishing DEI visibility, utilizing faculty and student feedback to optimize DEI initiatives, providing education on the DEI concept, and initiating a social assistance program for students. While the majority of survey respondents, generally, agreed with the proposed methodology for the Diversity and Equity components, the Inclusion component did not necessarily produce similar results.

Based on the responses, the least favored Inclusion method pertained to establishing and maintaining DEI visibility. As stated in Chapter 4, the purpose for DEI visibility is to aid in recruitment and retention efforts. Survey participants were questioned to gauge if they felt DEI visibility would have impacted their decision to attend the University [Figure 5.19]. As shown in Figure 5.19, only 28% of respondents agreed that highlighted DEI efforts and activities would have impacted their decision to attend the College of Engineering and Computing. This is not necessarily an adverse conclusion because there are many factors that impact prospective students' selection for higher education, such as financial aid, location, prestige of the academic programs, safety, etc. Therefore, based on the responses, the DEI visibility method may not significantly impact recruitment efforts.

If the engineering college aggressively highlighted DEI efforts and activities, would that have impacted your decision to attend the engineering college?

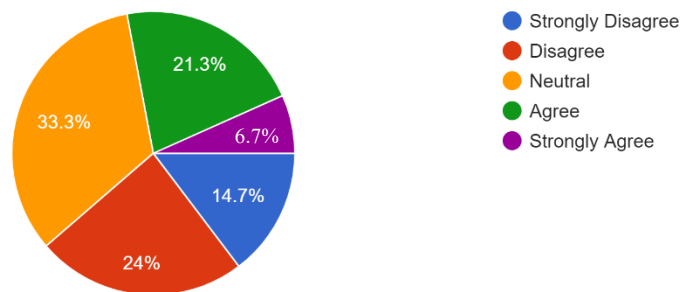


Figure 5.19 Perception on DEI Visibility for Engineering Colleges

However, 62.4% of respondents agreed that an inclusive environment can be established by highlighting minority professional clubs and cultural holidays [Figure 5.20]. Thus, respondents likely view DEI visibility more useful for retention efforts.

Do you feel that an inclusive environment can be established by highlighting minority professional clubs, culture holidays?

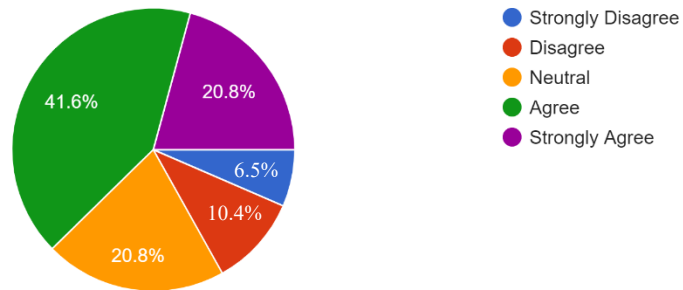


Figure 5.20 Perception on Highlighting Minorities

The remaining Inclusion questions received a majority vote. When asked about implementing periodic DEI training to uniformly embrace diversity, 51.4% of respondents agreed [Figure 5.21]. In addition to increasing the general understanding of the concept, respondents see the benefit training could have on building acceptance of diversity.

Do you feel that a periodic DEI training would be beneficial for the University population to uniformly embrace diversity?

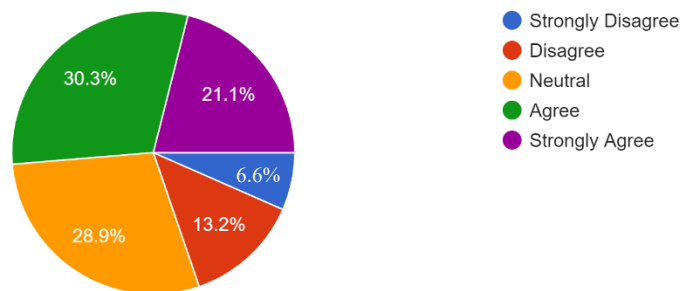


Figure 5.21 Perception on DEI Training Incorporated into Engineering Colleges

Would a mentorship program make you feel that your opinion matters to the engineering college?

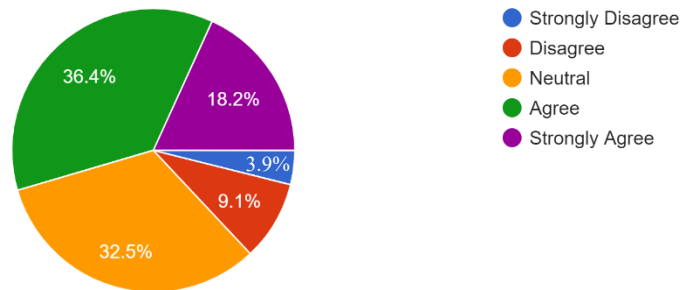


Figure 5.22 Perception on a Student Mentorship Program

Would a periodic survey to gain feedback and perspective on the level of inclusivity at the engineering college make you feel that your opinion is valued?

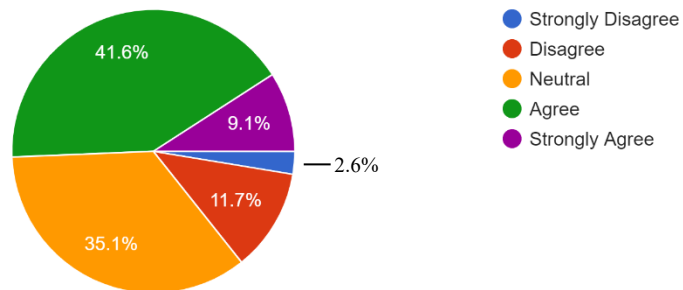


Figure 5.23 Perception on a Periodic Climate Survey

The last two survey questions served to gauge if the proposed methodology would make them feel that their opinion is valued. As shown, 54.6% agree that a mentorship program [Figure 5.22] and 50.7% agree that periodic climate survey [Figure 5.23] would make them feel that their opinion is valued.

## CHAPTER 6

### CONCLUSION

The engineering workforce is seeking to revolutionize the representation and culture of its employees. One popular method that is being adopted is the implementation of DEI initiatives to improve the overall experience for employees in the workplace. The DEI concept is quickly becoming a main component that is embedded into the core values of companies across various industries. However, for companies to fulfill their DEI initiatives, diverse pools of engineering graduates are needed. Thus, engineering education must be structured to produce these diverse graduate classes. I proposed a methodology designed to enhance engineering academic institutions by implementing the DEI concept into the administrative and educational frameworks. The hypothesis was tested by conducting a research study to gain the student perception on the proposed methodology. The survey respondents reflected a varied demographic pool that understood the importance of the DEI concept and was aware of the minority disparity within the engineering community.

In conclusion, the results of the research study support the proposed methodology and aligns with the hypothesis. With respect to the Diversity component of the proposed methodology, over 70% of the respondents are interested in learning from a diverse faculty and with a diverse student body. Based on this feedback, engineering academic institutions should assess the minority distribution of the faculty and student body and implement recruitment efforts to address the representation, accordingly. In reviewing the results for

the Equity component of the proposed methodology, over 50% of respondents were receptive to establishing a DEI strategic plan, instituting a committee or lead to oversee DEI initiatives, and providing access to financial resources for underprivileged or underrepresented students. Lastly, the Inclusion component received mixed feedback. Majority of respondents did not agree that DEI visibility would've impacted their decision to attend the University. This does not negate the methodology because there are many factors that influence prospective students' decision on higher education. However, the respondents did agree that developing DEI visibility by highlighting minority cultural holidays and professional organizations would foster an inclusive environment. Therefore, respondents voted in favor for DEI visibility serving as a useful retention tool versus a recruitment tool. In addition, majority of respondents agreed that administering a periodic climate survey to maintain awareness of the faculty and student experience, providing DEI education, and organizing a mentorship program to provide social assistance for students would establish a sense of belonging within the engineering academic community. Overall, 83.2% of survey respondents agree that it is important or very important for the engineering academic community to have diverse representation, equitable practices, and an inclusive environment.

As DEI becomes more political, the methodology's impact could be evaluated in advanced studies with respect to states who are proposing or passing legislation in opposition to DEI in education systems (e.g., Florida House Bill 999). Continued research could also include a study designed to test students' actual understanding of the methodology. Enhancing engineering education with the DEI concept supports the advancement of the engineering workforce by fostering the leading engineers of the future.

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## APPENDIX A

### RESEARCH STUDY QUESTIONS

The following list of questions were used in the research study that was approved by the University of South Carolina's Institutional Review Board.

#### Demographic Questions

1. What is your race?
2. What gender do you identify with?
3. Which do you identify as?
4. What level of education are you currently enrolled as?
5. Which economic level best represents your background prior to enrolling into college?

#### DEI Questions

1. Prior to today's presentation, how important was diversity to you?
2. Prior to today's presentation, how important was equity to you?
3. Prior to today's presentation, how important was inclusion to you?
4. Prior to today's presentation, how would you rate your level of understanding of the DEI concept?
5. Prior to today's presentation, were you aware of the racial and gender disparities within the engineering academic community?

6. Prior to today's presentation, were you aware of the racial and gender disparities within the engineering workforce?
7. After today's presentation, how would you rate your level of understanding of the DEI concept?
8. Following the presentation, do you feel that it is important for engineering colleges to have a diverse representation, equitable practices, and an inclusive environment?
9. Would you appreciate learning from a diverse faculty?
10. Would you appreciate learning with a diverse student body?
11. Would you appreciate if the engineering college established and implemented a strategic action plan with clear goals and measurable outcomes to incorporate the DEI concept?
12. Would you feel secure if a committee or lead was in place to oversee the DEI climate at the engineering college?
13. Do you feel it would be beneficial if the engineering college provided or partnered with a third-party organization to provide financial assistance to students from unprivileged or underrepresented backgrounds?
14. If the engineering college aggressively highlighted DEI efforts and activities, how would that have impacted your decision attend the engineering college?
15. Do you feel that an inclusive environment can be established by highlighting minority professional clubs, culture holidays?
16. Do you feel that a periodic DEI training would be beneficial for the University population to uniformly embrace diversity?

17. Would a mentorship program make you feel that your opinion matters to the engineering college?
18. Would a periodic survey to gain feedback and perspective on the level of inclusivity at the engineering college make you feel that your opinion is valued?