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# Exploring Engineering Students' Perceptions of Diversity and Inclusion in a Southern Public University: A Case Study

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**Abstract:** Understanding the present landscape of students' perceptions and the representation of diversity and inclusion within engineering textbooks is paramount for the effective development and execution of diversity and inclusion initiatives. This case study, conducted in the College of Engineering at the University of South Alabama, aims to assess the current perceptions of diversity among its engineering students. The study encompasses three fundamental elements: textbook evaluations, comprehensive student surveys comprising 30 questions that explore various facets of the engineering curriculum, student organizations, and the workforce, along with in-person interviews. The summarized findings provide invaluable insights for faculty, instructors, and administrators, facilitating informed decision making and program enhancement in the realm of diversity and inclusion.

**Keywords:** diversity; inclusion; engineering education; curriculum; instruction



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## 1. Introduction

Engineering students are fully engaged in acquiring technical knowledge and skills that will enable them to become competent professional engineers. However, there is a dearth of opportunities for them to recognize and embrace their responsibility to promote social justice, equity, and diversity in their future careers. This may be due to a lack of practice in thinking sociotechnically [1,2], which leaves them inadequately prepared for the workplace. According to a previous study, the engineering bachelor's degree recipients in the United States are predominantly male (81%) and white (67%) [3]. Unfortunately, diversity and inclusion in engineering fields lag behind other professions [4,5] and, while some engineering programs have taken steps to address this issue, many are unclear on how to transition to a more inclusive learning environment that connects with the engineering industry [6]. To bridge this gap, a transformative and collaborative model is needed that engages students, faculty, colleges, and industry in exploring effective strategies and practices that can create a just, equitable, and diverse workplace. With a looming workforce in engineering, it is anticipated that the industry will also benefit from the introduction of fresh ideas and perspectives brought by the integration of diversity and inclusion [7].

The engineering profession is embedded in dominant cultural norms that are often invisible to most students and faculty [8]. Students do not connect diversity and inclusion to engineering as a profession. Meanwhile, research has shown that, when students collaborate with peers from diverse backgrounds, they encounter novel approaches to problem solving, which foster creativity and innovation [9]. Additionally, diverse institutions contribute to increased innovation, problem-solving capabilities, and enhanced decision making [10]. Strategies that emphasize inclusivity, rather than solely focusing on the omission of identifiers, have shown promise in creating more equitable environments

and improving the academic performance of engineering students [11]. Furthermore, the success stories of prominent individuals from underrepresented backgrounds who have excelled in engineering, such as Dr. Ayanna Howard and Dr. Aprille Ericsson, provide tangible evidence of overcoming stereotypes and underscore the importance of diverse role models in fostering inclusivity [12–14]. Industry leaders also emphasize that diverse perspectives significantly contribute to the adaptability of the engineering sector, leading to increased innovation and a broader range of solutions to global challenges [9,10]. Thus, to cultivate an inclusive professional identity, engineers should possess the ability to apply disciplinary knowledge and appreciate how diversity strengthens the discipline, act inclusively and create inclusive environments, consider the impact of their endeavors on diverse populations, and engage in life-long learning related to engineering diversity, inclusion, and equity.

Amidst these lies the challenges of microaggressions. Microaggressions are subtle forms of bias, prejudice, and discrimination that impact women and minority students in engineering. In a comprehensive study conducted by Blume et al. [15], a correlation between microaggressions, self-reported alcohol use, and anxiety among minority students was revealed. Specifically, students of color reported experiencing significantly more microaggressions than their white counterparts, which were associated with lower perceived self-efficacy and a greater likelihood of engaging in alcohol drinking, leading to increased negative consequences related to alcohol use [15].

This underscores the importance of effective responses to microaggressions. Moreover, students perceived addressing these incidents as essential for effective management, and ignoring such incidents was viewed as less effective, emphasizing the significance of proactive measures in creating a supportive and inclusive academic environment [16]. Therefore, it is essential for engineering departments to incorporate training that emphasizes the effects of microaggressions on students. An inclusive curriculum that presents challenging ideas can help student development by encouraging them to make new connections with ideas in engineering and emphasizing human and social connections in engineering [17]. Karakhan et al. [18] identified ten indicators that influence the work environment in achieving diversity, equity, and inclusion (DEI) in the construction industry. These include ethnic and racial diversity at the company level, gender diversity and inclusion at the workforce level, corporate policy statements on diversity and inclusion, gender/ethnic diversity in leadership/management positions, knowledge and skill diversity, equitable pay/compensation at the industry level, equality, social justice, and non-discrimination policy statements, pay structure transparency, equitable pay/compensation at the company level, and merit-based transparent recruitment and promotion. By integrating diversity and inclusion, the engineering industry can benefit from the introduction of fresh ideas and perspectives.

Nonetheless, comprehending the perspectives of engineering students regarding diversity is an essential precursor to the effective implementation of inclusive practices. The University of South Alabama, situated in Mobile, AL, is a public university located on the Gulf Coast in the southern United States. The College of Engineering at the University of South Alabama offers four bachelor of science programs, namely Chemical and Biomolecular Engineering, Civil, Coastal, and Environmental Engineering, Electrical and Computer Engineering, and Mechanical, Aerospace, and Biomedical Engineering, all of which are accredited by the Engineering Accreditation Commission of ABET. As of Fall 2022, the college had 865 undergraduate students enrolled, and it boasts over ten student organizations. To promote diversity and inclusion, the College established a Diversity and Inclusion committee in 2021, with each department having a representative. However, there is a significant gap in the college's understanding of how its student body perceives diversity, inclusion, and the importance of diversity in the engineering curriculum, instruction, campus life, and careers. While there is a push for instructors to consider effective strategies in promoting inclusive teaching, it is crucial to systematically understand the thoughts of the student body before applying any strategies. It is, therefore, essential to

build a culturally responsive and inclusive engineering curriculum to foster a transformative and collaborative learning community to promote social justice, equity, and diversity in engineering education.

## 2. Materials and Methods

The objectives of this study are to evaluate the representation of engineering textbooks, understand engineering students' perceptions, and explore the roles and responsibilities of engineers in promoting social justice, equity, and diversity. The findings from this study will inform potential recommendations aimed at enhancing diversity in the engineering curriculum and learning environment. To achieve these objectives, we conducted three major tasks: a textbook evaluation, student surveys, and in-person interviews. The research questions were approved by the IRB board.

The three tasks were intentionally designed to gain insights for actionable understanding. The textbook evaluation provides a theoretical foundation, revealing the fundamental aspects of engineering education that may have influenced the students' perspectives. The student surveys provide a real-time representation of current attitudes, capturing diverse perceptions. The in-person interviews then enhance the narrative by adding personal stories and qualitative insights that complement the quantitative data obtained from the survey.

### 2.1. Textbook Evaluation

#### 2.1.1. Samples

The textbook evaluation consisted of three engineering textbooks subjected to comprehensive assessments. The evaluation focused on aspects such as character and author representation, diversity of perspectives, and the accurate portrayal of cultural nuances.

#### 2.1.2. Sample Analysis

To evaluate the cultural responsiveness of the textbooks selected, we adopted the modified culturally responsive-sustaining curriculum scorecard developed by Bryan-Gooden et al. [19]. The scorecard includes criteria such as character tally, author tally, representation, and social justice. The character and author tallies are used to assess the representation of characters from specific cultures by counting the symbolic representation of characters and authors by race, gender, and ability. Table A1 is used to track the number of characters and authors falling into each category presented in the textbook.

Table A2 is the scorecard adopted from [19] for evaluating the "representation" in terms of the diversity of characters and accurate portrayals in the textbook. The statements for the diversity of characters are designed to assess people of different cultures, skin tones, abilities, and other factors as depicted in the textbook and to what extent they are central to the story. Statements for accuracy are used to evaluate whether the characters accurately reflect the histories and experiences of their respective cultures. A culturally responsive textbook will present characters as multi-dimensional and avoid portraying them in stereotypical ways. Each statement on the scorecard is rated on a four-point scale ranging from "very satisfied" to "not satisfied" to evaluate the level of satisfaction with each criterion.

Table A3 is the scorecard for evaluating the social justice aspects of the textbook, adapted from Bryan-Gooden et al. [19]. It assesses three dimensions: decolonization/power and privilege, centering multiple perspectives, and connecting learning to real life and action, using a four-point scale ranging from "very satisfied" to "not satisfied".

### 2.2. In-Person Interviews

#### 2.2.1. Participants

For the in-person interviews, a selected group of six engineering students was chosen to ensure a diverse range of backgrounds, providing a comprehensive exploration of

perspectives. The selection process considered factors such as gender, race/ethnicity, and academic major.

### 2.2.2. Materials and Procedures

For the in-person interviews, four questions were asked by a research assistant through a virtual meeting. Question 1: What made you choose engineering as your major? Question 2: Do you think “diversity, equity, and inclusion are important in engineering”? Why do you think so? Question 3: How would you recommend the College of Engineering to promote diversity, equity, and inclusion? For example, faculty teaching and activities. Question 4: Any other thoughts and comments you would like to share with me?

### 2.2.3. Analytical Process

Upon the completion of the interviews, a thorough analysis of the open-ended responses was carried out using thematic analysis. This method allowed for the identification of recurring themes and patterns that emerged from the participants’ experiences and perspectives, as well as the identification of commonalities and differences among their responses. Valuable insights into the participants’ perspectives on diversity, equity, and inclusion in the field of engineering were gained through this analytical process.

## 2.3. Student Surveys

### 2.3.1. Participants

The participants in the student survey task comprised engineering students from diverse backgrounds enrolled in the College of Engineering at the University of South Alabama. Participation in the survey was voluntary, and respondents were informed about the purpose of the study, their rights as participants, and the confidentiality of their responses. To encourage participation and increase response rates, a gift card incentive was offered to participants in this survey, and at the end, a total of 73 responses were received.

### 2.3.2. Materials and Procedures

A descriptive survey methodology to gather insights into the engineering students’ perceptions and attitudes towards diversity and inclusion was used. The survey was administered using Google Forms and shared with all engineering students at the University via email. It comprised 30 questions, which were thoughtfully designed to elicit responses from students and were organized into four distinct sections, namely, Engineering Student Diversity, Student Organization and Involvement, Diversity in Workplace, and Demographic Information. Each section of the questionnaire aimed to collect comprehensive information on the students’ experiences and opinions regarding topics related to diversity and inclusion in the context of engineering education and the workplace.

The Engineering Student Diversity section (Table A4) was developed to gather data on the state of diversity in the university’s engineering student population. This section consisted of six Likert-type questions asking students to indicate the degree to which they agreed or disagreed with statements relating to diversity. Two multiple choice and three yes/no questions, some with an additional option for frequency, were also included in this section. An open-ended question that allowed students to provide short recommendations was also included. Questions such as “If you were the instructor, what would you do to promote diversity in Engineering?” and “If you were to give a score about your overall impression of the status of diversity in the University of South Alabama, which score would you give?” were among some of the questions in this section, which made them more appropriate for the University’s engineering student audience.

The Student Organization and Involvement section (Table A5) was added to understand how the engineering students felt about the representation of minority and underserved students in their respective student organizations, their opinions on the challenges of diversity, and how it can be promoted. This section consisted of nine questions which included three Likert-type questions asking students to indicate how well they agreed or

disagreed on issues relating to diversity and inclusiveness in their respective organizations. There were three multiple choice questions that allowed respondents to choose from a list of options with which they aligned. There were also two yes/no questions and one open-ended question asking students to provide the name(s) of the organization(s) they belonged to.

The Diversity in Workplace section (Table A6) in this study was developed to gather qualitative data about personal experiences related to discrimination and uncomfortable working environments in engineering workplaces among students who had internship, part-time, or full-time work experience. It consisted of seven questions in Likert-type, yes/no, and multiple choice form. This allowed for greater insights into the experiences of students who had already been exposed to the engineering industry, with a better understanding of the workplace dynamics in this field and how it affected their perceptions of diversity and inclusion. In addition, the survey also collected demographic data such as age, gender, race/ethnicity, place of birth, and academic major.

### 2.3.3. Analytical Process

The data obtained from the survey were analyzed using Python and Excel software. The survey items related to diversity practices were systematically coded and organized for analysis. The data were aggregated based on gender and ethnicity, allowing for a detailed exploration of attitudes and perceptions within these demographic categories. Percentages were then calculated to present a comprehensive overview of the response distribution, offering insights into the prevalence of specific attitudes across different groups. This categorization was necessary because of the low representation of minority ethnicities that participated in the survey. It was intended to capture the demographic diversity of the surveyed population and facilitate a more nuanced analysis of the responses.

Additionally, comparative analyses were conducted, employing the Mann–Whitney U test to identify potential significant differences in responses based on gender and ethnicity. For the Mann–Whitney U test, the test statistics (U) and  $p$ -values for each of the responses were obtained, which are presented in Table A7. The  $p$ -values were used to determine the significance of the observed differences. A significance level (alpha) of 0.05 was adopted, and  $p$ -values less than this threshold were considered to be indicative of statistically significant differences in the responses between the categories considered. This approach ensured a rigorous evaluation of the data, shedding light on meaningful patterns and disparities that might exist among diverse demographic groups. Furthermore, open-ended responses were analyzed using a thematic analysis to identify recurring themes.

## 3. Results and Discussion

### 3.1. Civil Engineering Textbook Evaluation Results

Table 1 presents the evaluation results for the textbook, along with the evaluation categories and criteria. The first column (1, 2, and 3) corresponds to the different textbooks under consideration. In terms of the representation categories, out of the three textbooks evaluated, two were classified as having “emerging awareness” with representation scores falling between 1 and 11, while the remaining textbook was categorized as being “culturally insufficient”. On average, the engineering textbooks evaluated demonstrated cultural insufficiency, indicating a lack of culturally and historically accurate portrayals of characters and stories. This deficiency is likely attributable to a lack of diversity among textbook contributors and illustrators.

According to the social justice score, all of the evaluated textbooks demonstrated cultural insufficiency. These textbooks provide minimal opportunities for teachers to promote cultural responsiveness, and students are not sufficiently encouraged to think critically or take action to combat inequity, as the textbooks have weak connections to their lived experiences. However, the textbook classified as having “emerging awareness” does offer some opportunities for teachers to practice cultural responsiveness. This textbook

also acknowledges non-dominant knowledge systems, though this is only seen a few times throughout the text.

**Table 1.** Textbook evaluation results.

Textbook Number	Diversity of Characters Tally	Diversity of Authors Tally	Representation	Social Justice	Total
1	81	2	−8	0	−8
2	4	4	5	0	5
3	0	5	2	−4	−2
Average	28.3	3.7	−0.3	−1.3	−1.7
Representation Category	Culturally Destructive (−26 to −11); Culturally Insufficient (−10 to 0); Emerging Awareness (1 to 11); Culturally Aware (12 to 19); Culturally Responsive (20 to 26)				
Social Justice Category	Culturally Destructive (−16 to −7); Culturally Insufficient (−6 to 0); Emerging Awareness (1 to 7); Culturally Aware (8 to 12); Culturally Responsive (13 to 16)				

In reviewing a textbook about “Civil Engineering Materials”, twelve characters were identified solely by their profession, such as engineer, construction worker, or architect, without any additional details provided. Of the remaining characters, four were identified as being female and six as male, with no mention of their race. The bottom row of the table, which is empty, indicates that race was not mentioned for any characters when gender was not specified. An analysis of the data suggests that the textbook leans towards depicting Caucasian males, Asian females, and characters with no information about their race or ethnicity, which warrants further investigation.

Neither the sample problems nor the practice problems in the textbook make any reference to race or gender, and the problems themselves typically address the reader as the individual performing the calculations or procedures. In fact, the terms “white”, “black”, “Asian”, “African”, “male”, “female”, “he”, and “she” are never used to describe individuals in the main body of the text, unless they are referring to a material. The figures in the textbook primarily consist of images of equipment, materials, and buildings, with any people shown being partially visible or obscured by the black and white color scheme. However, the occupations of “construction engineer”, “Geotechnical engineer”, and “structural engineer” are mentioned 26, 2, and 3 times, respectively, in the main text, which is likely due to the focus of the textbook on these subjects, rather than any intentional bias.

After reviewing Hartman [20] and other similar studies, it is common practice to chart data over several years to identify trends and changes over time. In this case, we could use different editions of the textbook or perhaps other textbooks to represent different years. For example, we could use the CE Materials textbook to represent 2011 and analyze several newer textbooks from more recent years to see if any changes have been made regarding the use of color images, the representation of people in the images, or the mention of race and gender in the text.

### 3.2. Students’ Perception Survey Results

#### 3.2.1. Demographic Information of Participant

Descriptive statistics were collected to identify the participants and their self-identified demographic information. This information was aggregated and is presented in Table 2. A total of 73 Engineering students responded to the survey, with a majority of them (56.2%) majoring in Civil, Coastal, and Environmental Engineering, followed by Mechanical Engineering (37.0%) and Chemical and Biomolecular Engineering (4.1%). The participants were predominantly male (69.9%), aged between 20 and 24 years (69.4%), and a significant proportion was born and brought up in the United States (91.9%), with a few participants from other countries such as Nigeria, China, Bangladesh, Kosovo, and Mexico. Most participants identified as Caucasian (67.1%), while 11.0% identified as having two or more ethnicities. Regarding their education level, most participants were either juniors

(41.1%) or seniors (28.8%), while freshmen (8.2%), sophomores (15.1%), and graduate students (6.8%) made up the rest. The largest group of participants identified as slightly conservative (30.1%), followed by very conservative (17.8%) and slightly liberal (20.5%). Most participants were single (86.3%), while 12.3% identified as married.

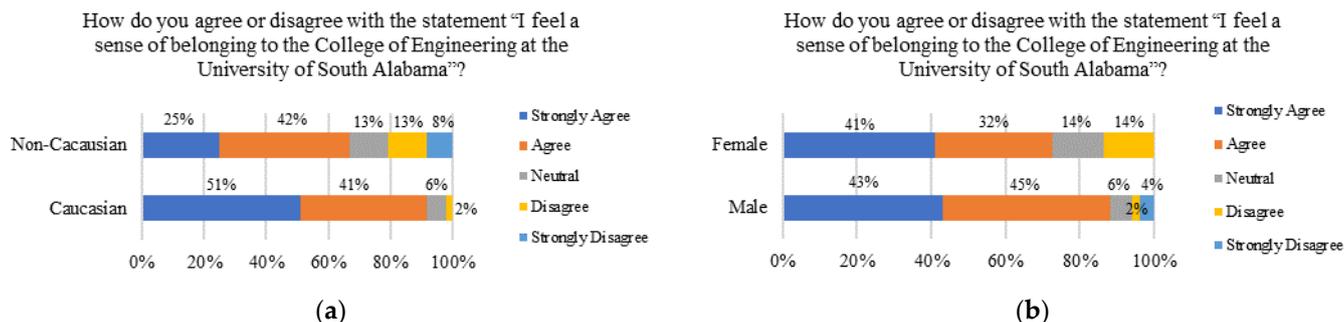
**Table 2.** Demographic information of survey respondents.

Item	Variables	No.	Percentage
Major	Electrical Engineering	2	2.7%
	Chemical and Biomolecular Engineering	3	4.1%
	Mechanical Engineering	27	37.0%
	Civil, Coastal and Environmental Engineering	41	56.2%
Gender	Male	51	69.9%
	Female	22	30.1%
Age	20–24	50	69.4%
	25–29	13	18.1%
	30–34	6	8.3%
	>40	3	4.2%
Ethnicity	Caucasian	49	67.1%
	African-American	7	9.6%
	Latino or Hispanic	2	2.7%
	Asian	5	6.8%
	Native American	1	1.4%
	Two or More	8	11.0%
Marriage Status	Other/Unknown	1	1.4%
	Single	63	40.6%
	Married	91	58.7%
School Level	Prefer not to say	1	0.6%
	Freshman	6	8.2%
	Sophomore	11	15.1%
	Junior	30	41.1%
	Senior	21	28.8%
Political View	Graduate Student	5	6.8%
	Very liberal	8	11.0%
	Slightly liberal	15	20.5%
	Slightly conservative	22	30.1%
	Very conservative	13	17.8%
	Prefer not to say	15	20.5%

### 3.2.2. Engineering Student Perceptions of Diversity

- General Perception about College and University

The engineering students were asked to share their perceptions on the state of diversity, equity, and inclusion in the University. While the majority of the respondents felt a sense of belonging to the College of Engineering, it is essential to highlight that demographic factors significantly influence these perceptions. The results from the survey, represented in Figure 1, show that white engineering students were the most likely to report a sense of belonging when compared to non-white students ( $U = 368.0$ ,  $p = 0.005$ ). Caucasian participants generally agreed (51% strongly agree and 41% agree) with feeling a sense of belonging to the college. In contrast, only 25% of non-Caucasian respondents strongly agreed, while 42% agreed. Additionally, male respondents reported a slightly higher sense of belonging compared to females, with 43% strongly agreeing and 45% agreeing, while only 41% of females strongly agreed and 32% agreed. Notably, a high percentage of non-Caucasians and a slightly high percentage of females expressed a lack of sense of belonging compared to their other counterparts.



**Figure 1.** Feeling of sense of belonging to the College of Engineering by: (a) ethnicity and (b) gender. **Note:** In some figures, the number may not always add up to exactly 100% due to rounding to the nearest whole number.

These observed disparities align with the existing literature [21–23], which attributed this to the lack of cultural and gender representation affecting students' perceptions of inclusivity and sense of belonging. For instance, Fan et al. [23] found that a lack of representation and a sense of isolation could hinder minority students' sense of belonging in higher education. Similarly, gender-related differences in perceived belonging have been explored by Rainey et al. [21]. They noted that women in STEM fields may experience a less supportive environment, affecting their sense of belonging. This underscores the importance of fostering diverse and inclusive atmospheres to enhance students' sense of belonging.

Furthermore, the majority of the respondents indicated sufficient knowledge and understanding of diversity and strongly agreed with the statement affirming diversity's benefit and importance in engineering. A significant proportion of both Caucasian (76%) and non-Caucasian (75%) respondents understood and valued diversity, considering it important to engineering. Surprisingly, more females (86%) than males (64%) expressed a strong understanding and appreciation for diversity in engineering (Figure 2). The students were provided with the definition of diversity as "the presence of differences in any sense such as gender, age, ethnicity, nationality, religion, and sex orientation" and asked to indicate the degree to which they agreed with the statement affirming the importance of diversity to engineering. The results (Figure 3) showed that some of the male engineering students, who had initially indicated the importance of diversity in engineering, changed their perception and now considered it to be less important ( $U = 765.5$ ,  $p$ -value = 0.005). Female perception, on the other hand, remained the same, indicating the great importance of diversity in engineering. This indicates that, while the majority of the students perceived diversity to be important to engineering, the majority of male students had a different understanding of what diversity means, as indicated by the change in their opinion after being provided with the definition of diversity.

Furthermore, more than one third of the respondents claimed to have been discriminated against or encountered an uncomfortable learning environment due to their race, gender, or for any other reasons, with 5% of these respondents indicating experiencing discrimination frequently, 11% sometimes, and 22% rarely. As indicated in Figure 4, ethnicity-wise, non-Caucasian engineering students were more likely to be discriminated against or encounter an uncomfortable learning environment compared to their counterparts ( $U = 787.0$ ,  $p$ -value = 0.007). In terms of gender, female engineering students reported a higher rate of discrimination ( $U = 806.5$ ,  $p$ -value = 0.001) than other students. The higher rate of discrimination expressed by some females must have been due to the compounded effects of race and gender biases. This concept of intersectionality, well-established in the literature, posits that individuals experience intersecting social identities that contribute to unique and often compounded forms of discrimination [24].

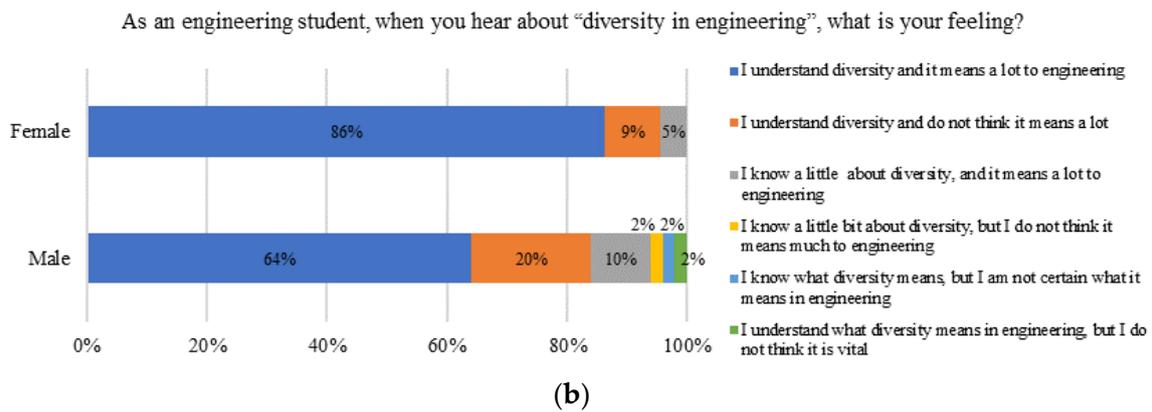
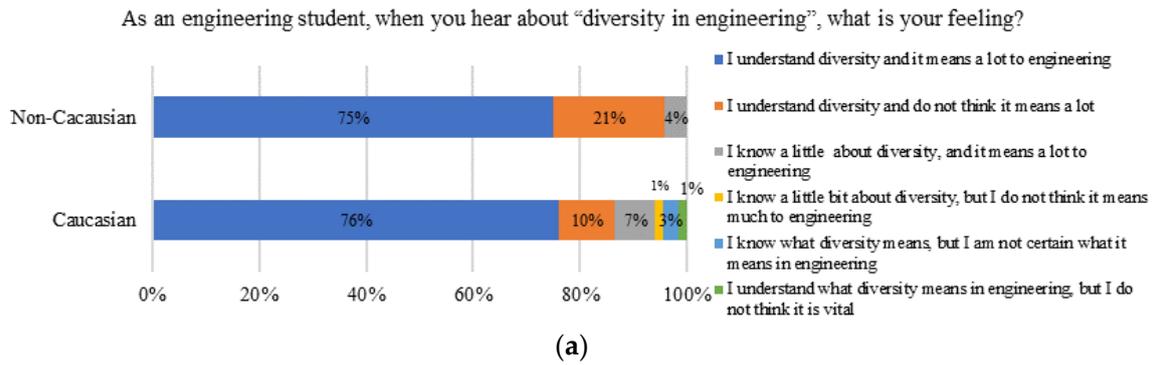


Figure 2. Students perception on the knowledge and importance of diversity in engineering based on (a) ethnicity and (b) gender.

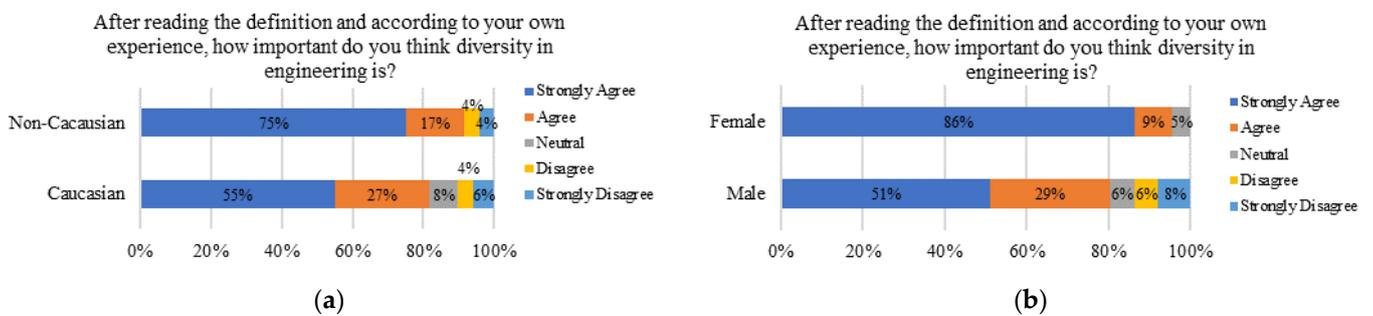


Figure 3. Student’s perception on the importance of diversity after being provided with the definition of diversity based on (a) ethnicity and (b) gender.

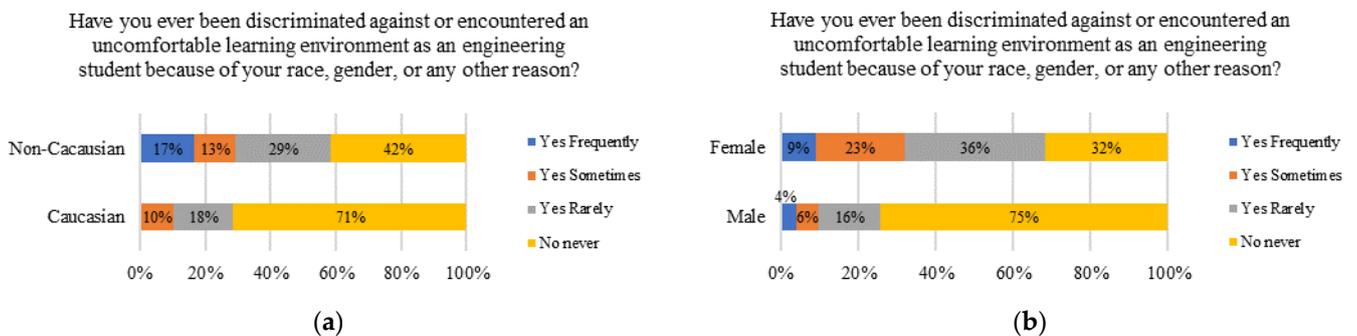
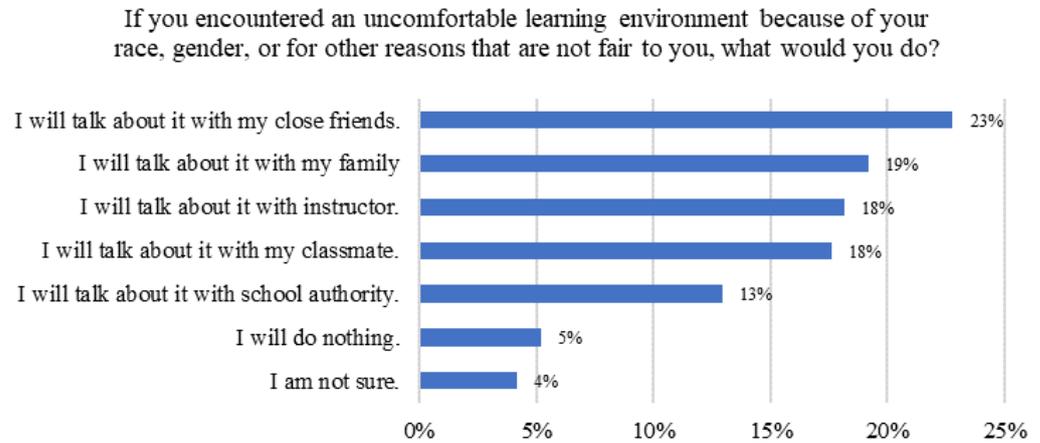


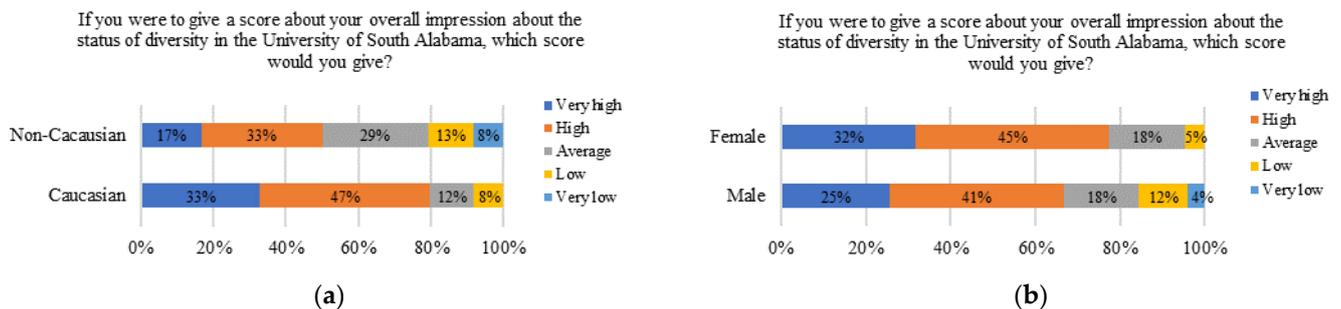
Figure 4. Frequency of discrimination experienced by engineering students based on (a) race and (b) gender.

Irrespective of ethnicity or gender, the engineering students would either talk to friends or family, and a lesser percentage would talk to the instructor, classmate, or school authority when faced with an uncomfortable learning environment resulting from their race, gender, or any other reason (Figure 5).



**Figure 5.** Attitude toward discrimination among students.

The survey results regarding the overall impression of the status of diversity at the University of South Alabama reveal interesting patterns among the respondents. As shown in Figure 6, more than 50% of the surveyed students rated the University as either very high or high (rating of 7 and above out of 10). In terms of racial perception, a significant portion of Caucasian (80%) respondents perceived the diversity status as being high or very high, indicating a generally positive outlook. However, a notable proportion of non-Caucasian respondents (50%) expressed a dissatisfied perception ( $U = 391.0$ ,  $p$ -value = 0.015). This is mostly a reflection of the disparities in the feeling of a sense of belonging among the ethnic groups, indicating more room for improvement in addressing diversity-related concerns. When examining gender perception, a slightly higher percentage of female respondents (77%) than male respondents (66%) perceived the university's diversity status as being high or very high. These findings highlight a positive perception of diversity at the university, particularly among females. Nonetheless, the presence of respondents who perceived this diversity as being average or low emphasizes the importance of increasing ongoing efforts to enhance inclusivity and address any existing disparities.

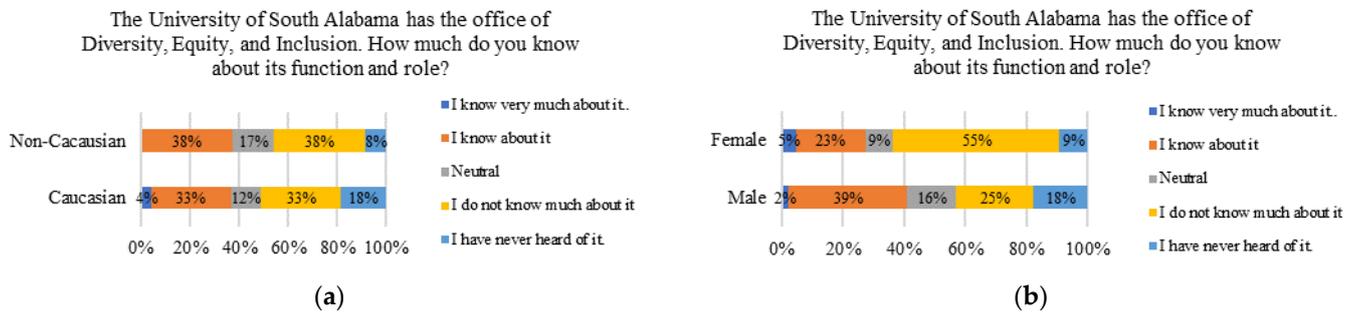


**Figure 6.** Engineering students' ratings on the status of diversity in the university across (a) ethnicity and (b) gender.

While the disparity in ratings across the considered demographics is consistent with Boyd-Sinkler et al.'s findings [25], the higher rating for females is in contrast with the low rating observed by the researcher. According to the report, women, as a minority group in engineering, face more challenges and barriers than men and thus may have a lower perception of diversity and inclusion [25]. While this is true, the higher rating from the female respondents observed in the present survey must have been influenced by

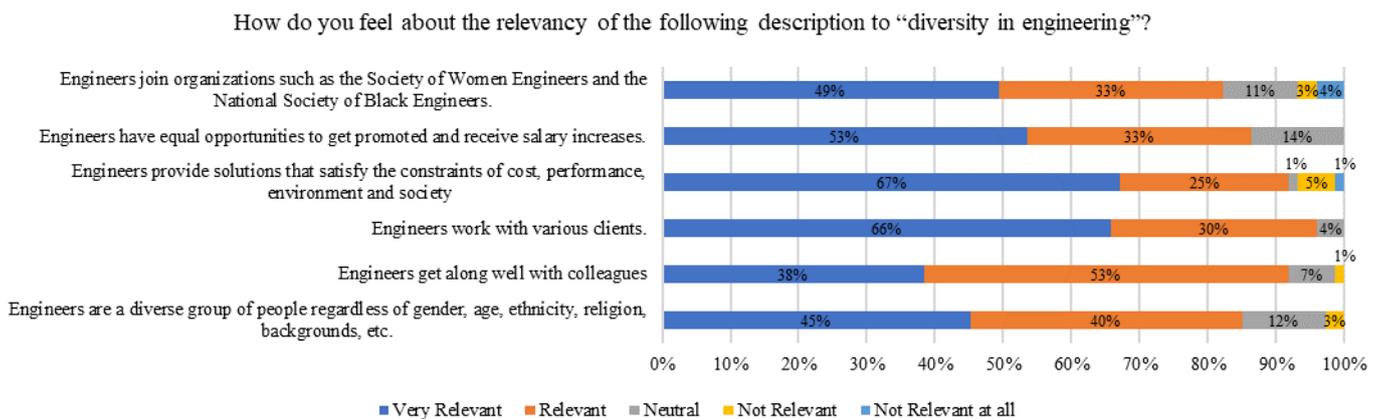
various factors, such as personal experiences, campus climate, and awareness of diversity initiatives. Nevertheless, the presence of respondents who perceived the diversity as being average or low emphasizes the importance of ongoing efforts to enhance inclusivity and address any existing disparities.

While most (69.9%) engineering students were aware of the University’s Office of Diversity, Equity, and Inclusion, less than one third knew about or very much about its role. As observed in Figure 7, while women tended to have a slightly lower awareness about its existence and role, this lack of awareness was relatively consistent across all ethnic groups. These findings underscore the need for increased awareness and communication about the role and functions of the Office of Diversity, Equity, and Inclusion. The office plays a crucial role in fostering an inclusive environment, and efforts should be made to enhance its visibility, ensuring that all members of the university community are aware of its functions and resources.



**Figure 7.** Awareness of the office of Diversity, Equity, and Inclusion among (a) ethnicity and (b) gender.

As part of the survey, the respondents were asked to articulate the importance they attributed to various descriptors concerning diversity in engineering. Key statements encompassed the belief in engineers’ diversity, positive colleague interactions, collaboration with clients, comprehensive problem solving, equal career opportunities, and participation in professional organizations such as the Society of Women Engineers and the National Society of Black Engineers. The response analysis is summarized in Figure 8.



**Figure 8.** Students’ perception of the relevancy of some descriptions of diversity in engineering.

As observed in Figure 8, a notable area of agreement among the respondents was the perceived high relevancy of engineers being a diverse group, with 85% of students considering this to be either “Very Relevant” or “Relevant.” This indicates a strong endorsement and wide belief in the pivotal role of diversity in shaping the engineering landscape. Moreover, a significant majority of students (91%) expressed the importance of engineers possessing strong interpersonal skills and collaborating effectively with colleagues. This consensus

highlights the acknowledged significance of positive colleague interactions in fostering a collaborative and inclusive engineering environment. In addition, the engineering students recognized the importance of working with various clients as a form of promoting diversity in engineering, with a unanimous agreement (96%) among the students. This unanimity reflects the understanding that adaptability and client engagement are crucial aspects of successful engineering practice. The statement emphasizing the need for engineers to provide solutions that satisfy technical, cost, performance, environmental, and societal factors also garnered significant concession, with 92% of the students deeming it either "Relevant" or "Very Relevant." This underscores the holistic perspective that the students attributed to problem solving in the engineering domain. Regarding equal opportunities for career advancement and salary increases, 86% of the students perceived this as being either very relevant (53%) or relevant (33%) to diversity in engineering. This finding suggests an awareness among the students of the connection between equal opportunities and a diverse and inclusive engineering profession. In terms of participation in organizations like the Society of Women Engineers and the National Society of Black Engineers, there was a general consensus, with 82% of students viewing such involvement as being "Very Relevant" or "Relevant." This alignment underscores the recognition of the role of professional organizations in promoting diversity and inclusivity within the engineering community.

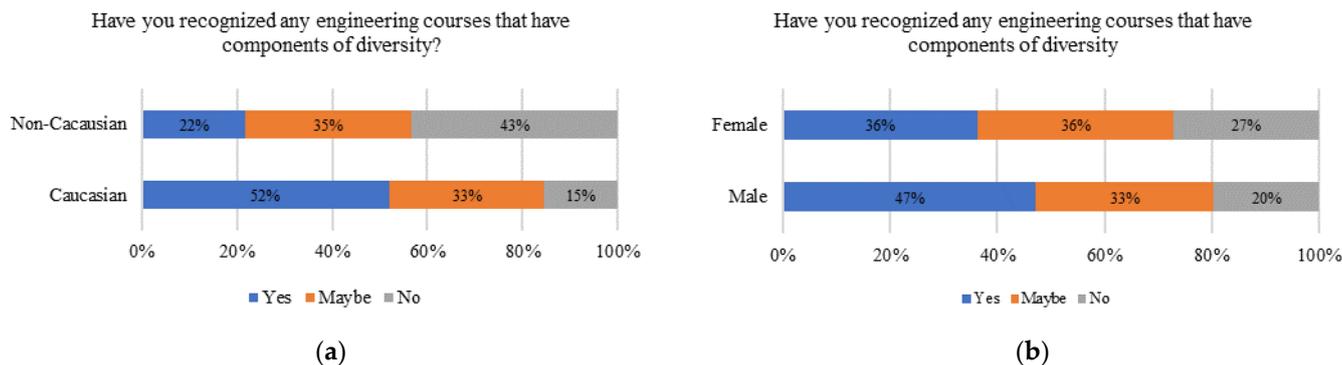
The findings collectively reveal an informed perspective among the students regarding the importance of various perceptions relating to diversity in engineering. It is to be noted that this perception was consistent, irrespective of ethnicity or gender. The high level of agreement on the significance of diversity, positive interactions, client engagement, comprehensive problem solving, equal opportunities, and participation in professional organizations reflects a comprehensive agreement and understanding of the multifaceted nature of diversity within the engineering profession.

Overall, the perceptions of the surveyed engineering students showed a general positive attitude towards diversity, equity, and inclusion and their importance in engineering. However, a significant percentage of the students reported experiencing discrimination or uncomfortable learning environments based on their race, gender, or for other reasons. This highlights the need for faculty members, staff, and administrators to think about what they can do to address and eliminate such biases and create a more inclusive environment. The fact that only a minority of students were aware of the role of the Office of Diversity, Equity, and Inclusion suggests that the University could do more to promote its diversity initiatives. On the other hand, the diverse range of ideas on promoting diversity in engineering shows that there is no one-size-fits-all approach, so instructors can adapt to the common needs and opinions of their students.

- Diversity in Textbooks and Curriculum

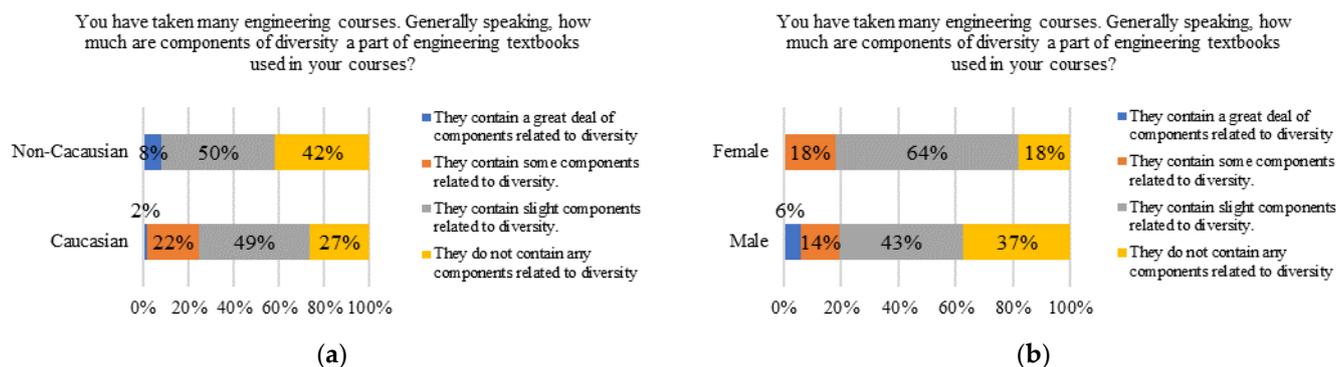
In pursuing diversity and inclusion in engineering education, an essential aspect involves integrating diversity-related components into engineering courses and textbooks. This section delves into the responses from both students and faculty regarding their observations of diversity components in engineering courses and the presence of diversity-related content in the textbooks used.

Regarding recognizing diversity components in engineering courses, the majority of the respondents believed that the syllabus and courses offered in the field of engineering at the University did not reflect diversity or talk about diversity (Figure 9). However, there were disparities based on ethnicity and gender. Caucasians were more likely to recognize diversity components in their engineering courses compared to non-Caucasians ( $U = 364.5$ ,  $p$ -value = 0.004). Specifically, 52% of Caucasian respondents affirmed the presence of diversity-related elements, while 22% of non-Caucasian respondents acknowledged the existence of such components. Additionally, almost the same percentage of male and female engineering students indicated having recognized components of diversity in their courses.



**Figure 9.** Engineering students' perception of the presence of components of diversity in engineering courses: (a) ethnicity and (b) gender.

Furthermore, the survey results on diversity in engineering textbooks (Figure 10) reveal that around half of the respondents, regardless of ethnicity, perceived at least slight diversity components in their engineering textbooks. On the other hand, a notable number, especially among non-Caucasians (42%) and males (37%), felt that these textbooks did not contain diversity components. Notably, none of the females reported a significant presence of diversity components in their textbooks. The prevalent perception that the majority of engineering textbooks inadequately address diversity aligns with our earlier analysis in the preceding section, reinforcing the consistency of these findings.

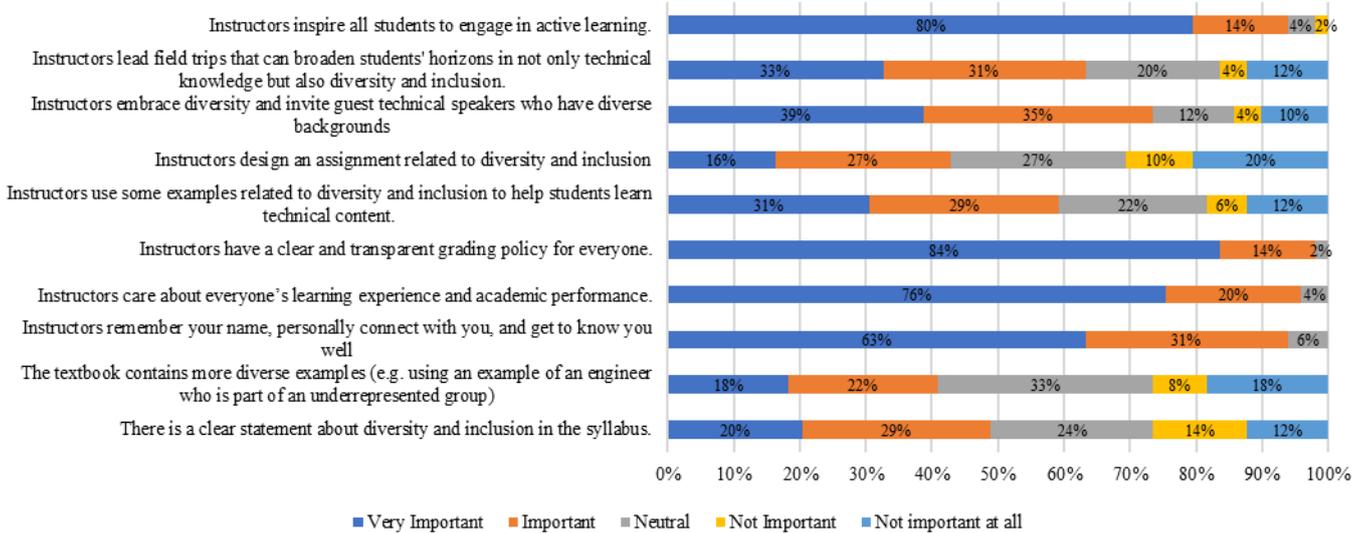


**Figure 10.** Engineering students' perception of the presence of components of diversity in engineering textbooks: (a) ethnicity and (b) gender.

Furthermore, the engineering students shared their thoughts on promoting diversity in engineering education through responses provided to a multiple choice question, "How do you view the importance of the following practices that can promote diversity in an engineering course?". The responses were analyzed and are summarized in Figures 11 and 12. From the data presented in Figures 11 and 12, it can be seen that there was a consensus among the engineering students regarding the importance of inspiring students to engage in active learning, as well as the need for instructors to have a clear grading policy that applies to everyone to promote diversity. Moreover, the majority of the respondents emphasized the significance of instructors building personal connections with students and caring about their learning experience. However, there were slight differences in opinion when it came to designing assignments that relate to diversity and inviting diverse guest speakers. Females ( $U = 802.0, 785.5; p\text{-value} = 0.003, 0.004$ ) and non-Caucasians ( $U = 771.5, 772.0; p\text{-values} = 0.027, 0.020$ ) appeared to place more importance on these aspects compared to males and Caucasians. Similarly, while almost half of the respondents recognized the value of field trips in promoting diversity, non-Caucasians assigned a higher significance to these factors than their counterparts ( $U = 812.5, p\text{-value} = 0.005$ ). Female engineering students,

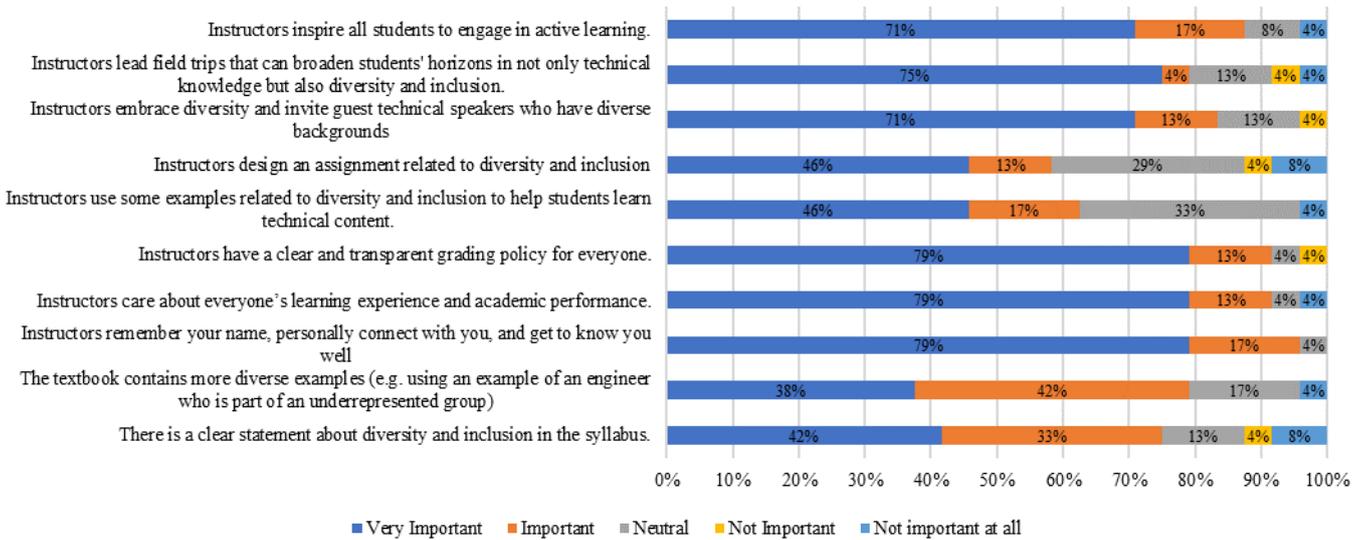
on the other hand, placed more importance on the need for instructors to include diverse examples in the syllabus than their male counterparts ( $U = 743.5, p\text{-value} = 0.023$ ).

How do you view the importance of the following practices that can promote diversity in an engineering course?



(a)

How do you view the importance of the following practices that can promote diversity in an engineering course?



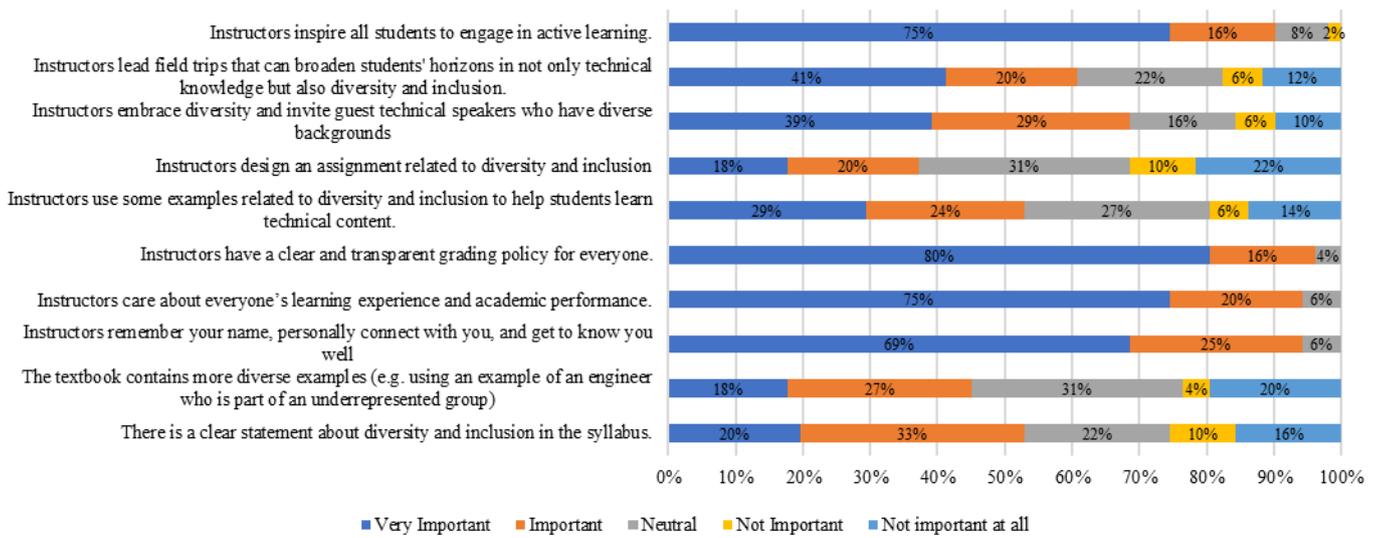
(b)

**Figure 11.** Student level of relevance to key practices for promoting diversity in engineering based on ethnicity: (a) Caucasian and (b) non-Caucasian.

Based on the open-ended question, “If you are an instructor, what will you do to promote diversity in engineering?”, we are able to assess the reason behind some of these discrepancies across ethnicity and gender. A few of the students felt it was unnecessary to explicitly promote diversity. For example, one of the respondents mentioned, “I would not make a huge deal about it. We do not go by white engineers, black engineers, etc. It is good to incorporate different cultures but to make a point is very unnecessary and honestly inappropriate. You would be stating the obvious to the observer. We all notice when something is different from the way we usually do it”. Some of the Caucasian and male respondents indicated that diversity should be focused on by treating all students equally

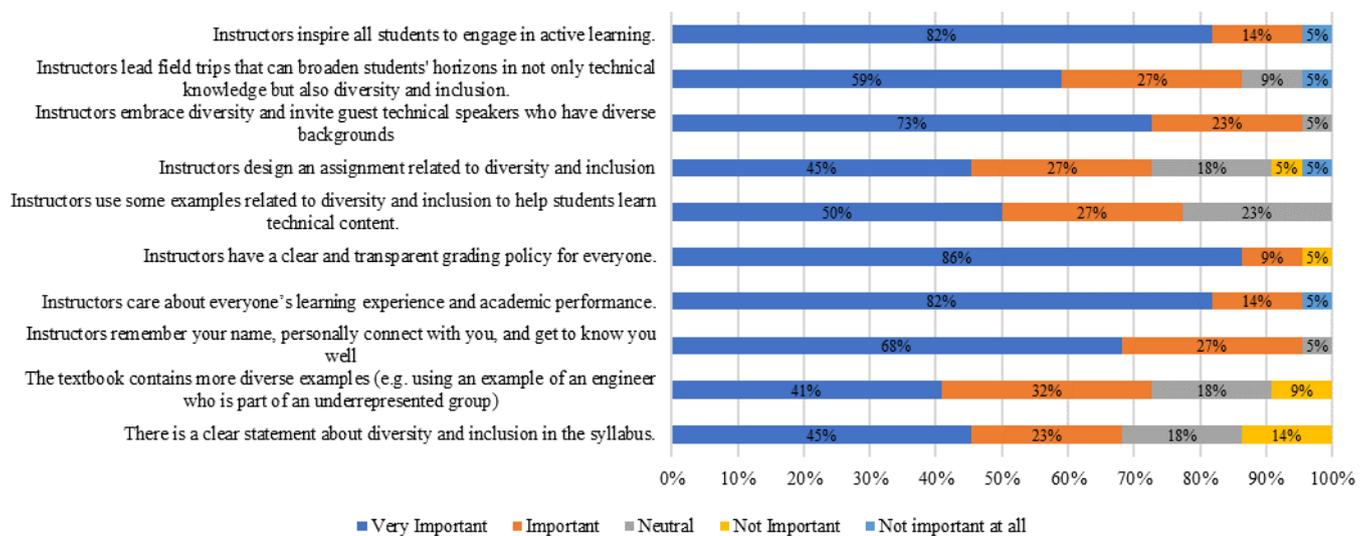
and creating an inclusive environment where everyone feels valued and respected. This includes instructors actively seeking out and listening to feedback from students, having a clear and transparent grading policy for everyone, and inspiring all students to engage in active learning, as well as checking in with students who may be struggling to connect with their peers or feel intimidated by their instructors. Another common suggestion was to incorporate diverse perspectives and examples in class, while some recommended hiring and recruiting both faculties and freshmen from diverse backgrounds. Some respondents also mentioned the importance of promoting diversity through engineering organizations, such as by sponsoring groups that are focused on underrepresented communities.

How do you view the importance of the following practices that can promote diversity in an engineering course?



(a)

How do you view the importance of the following practices that can promote diversity in an engineering course?



(b)

Figure 12. Student level of relevance to key practices for promoting diversity in engineering based on gender: (a) male and (b) female.

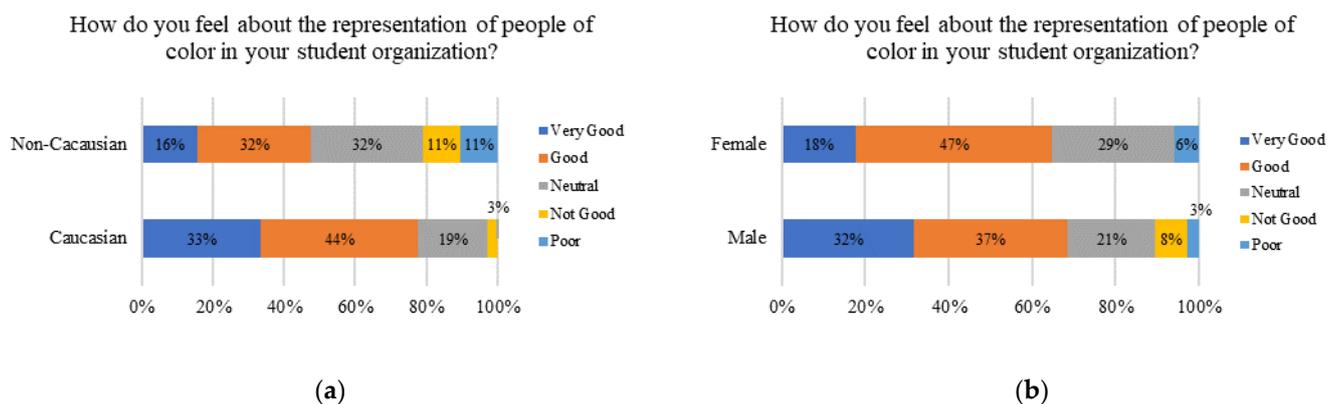
The consensus observed in our survey findings aligns with the existing literature emphasizing the critical role of inspiring students' active learning in engineering education.

The previous studies [26,27] highlight the positive impact of active learning on student engagement, comprehension, and overall academic success. The importance placed on a clear grading policy resonates with recommendations from Wilson [28], emphasizing transparent assessment practices as being a key factor in student achievement and satisfaction. Feldman [29] identified biases against minorities in grading methods, underscoring the need for transparency. The slight differences in opinion regarding the use of diverse examples in teaching and inviting diverse guest speakers find support in the broader literature on diversity in education. The study by Moreu et al. [30] underscores the significance of diverse role models and perspectives in enhancing the educational experiences of underrepresented groups. Additionally, the observed higher importance placed by females and non-Caucasians on certain diversity-promoting initiatives echoes the findings from studies by Peixoto et al. [31] and Salehi et al. [32], which indicated that underrepresented groups often value curriculum and instructional practices that reflect their own experiences. Such insights underscore the need for tailored strategies to address diverse preferences and enhance inclusivity in engineering education.

### 3.2.3. Student Organization and Involvement

Various information about the engineering students' involvement in student organizations, perceptions of diversity within these organizations, opinions on the diversity initiatives undertaken by the University, and how diversity can be promoted were unearthed by this section of the survey data. Out of the seventy-three survey respondents, fifty students (68.5%) indicated that they belonged to one or more student organizations, with the American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), and Society for Women in Engineering (SWE) being some of the most common among the students. Among the students were officers (19/26%), very active members (9/12.3%), slightly active members (12/16.4%), members who were not involved (10/13.7%), and nonmembers (23/31.5%) of a student organization.

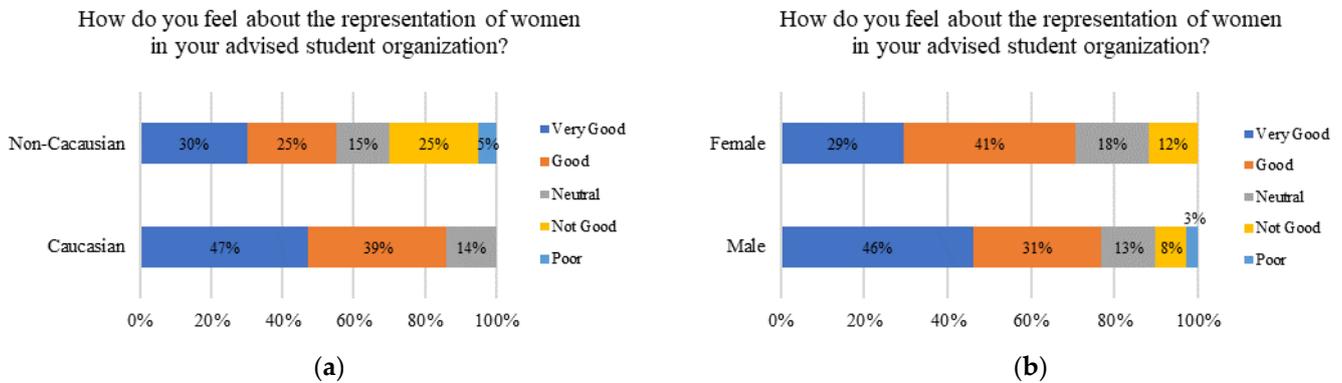
Concerning the representation of people of color in student organizations, this survey report (Figure 13) found that about half (67%) of the students felt either "Very Good" or "Good" about the representation in their respective student organizations. This sentiment was mirrored in the assessment of women's representation (Figure 14), where 76% of the respondents expressed positive views, categorizing it as either "Very Good" or "Good."



**Figure 13.** Perception based on (a) ethnicity and (b) gender of engineering students on the representation of people of color in student organizations.

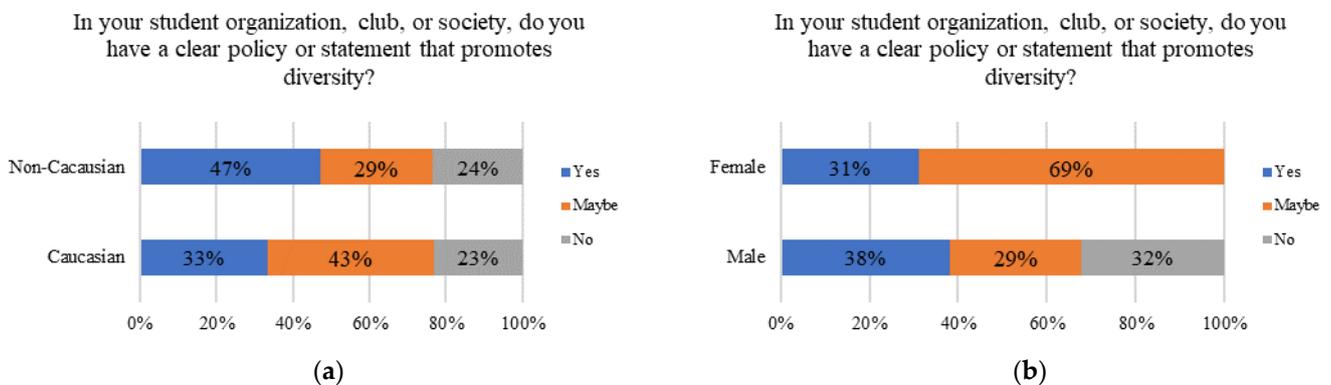
When analyzing the data based on demographics, it becomes evident that both males and females had almost the same level of positive perception of the representation of people of color and women, but males tended to have a slightly stronger perception. Conversely, non-Caucasian engineering students expressed a different view, with the majority feeling neutral or dissatisfied with the representation of women and people of color in their respective student organizations ( $U = 232.5, 214.0$ ;  $p$ -values = 0.021, 0.018). While this might

indicate an underrepresentation of women and people of color in student' organizations, it is important to note that cultural factors may have also contributed to variations in how individuals perceived the representation of different groups [33]. These cultural factors could impact the interpretation of representation within the student organizations.



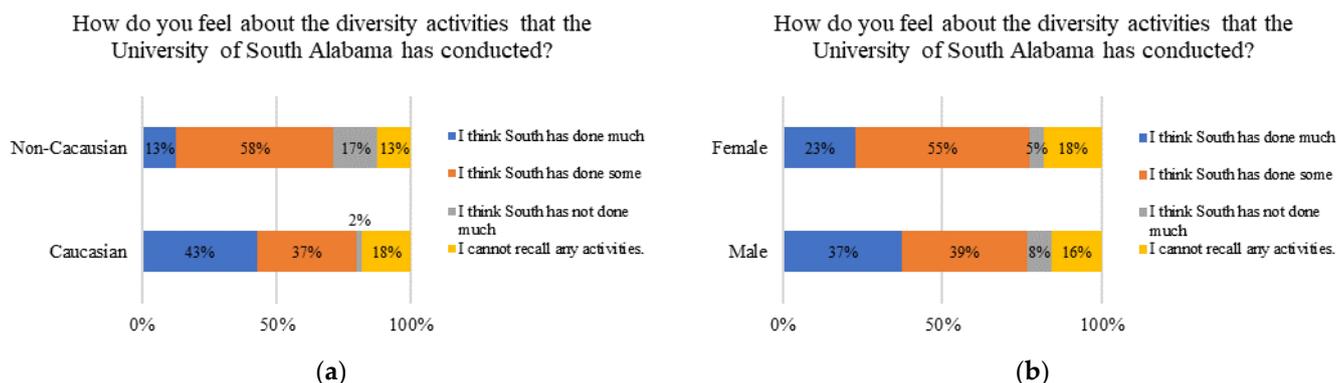
**Figure 14.** Perception based on (a) ethnicity and (b) gender of engineering students on the representation of people of women in student organizations.

With regards to diversity initiatives within student organizations (Figure 15), the students were asked if there is/are any clear policies or statements that promote diversity in their respective student organizations. The survey revealed mixed perceptions regarding diversity policies within student organizations. While 33% of Caucasians and 47% of non-Caucasians claimed to have clear diversity policies, a significant portion (43% of Caucasians, 29% of Non-Caucasians) were uncertain ("Maybe").



**Figure 15.** Student's perception of diversity promoting policies across (a) ethnicity and (b) gender.

There was also variance in the perceptions of the University's diversity activities (Figure 16), with 43% of Caucasians believing the university had undertaken much, compared to 13% of non-Caucasians. Gender differences showed that 38% of males and 31% of females believed there were clear diversity policies in their student organizations. While most respondents viewed the university's diversity-promoting activities positively, there was a notable proportion (24% of males and 23% of females) who believed the university has not achieved enough. This clearly indicates that, while we notice the presence of clear diversity policies within some student organizations in the university, there exists a lack of awareness within student groups regarding these policies as well as the diversity promotion efforts conducted by the school. Thus, there is a need for enhanced communication and engagement strategies within student organizations on diversity-promoting initiatives. This, in turn, can contribute to a more cohesive and supportive campus community.

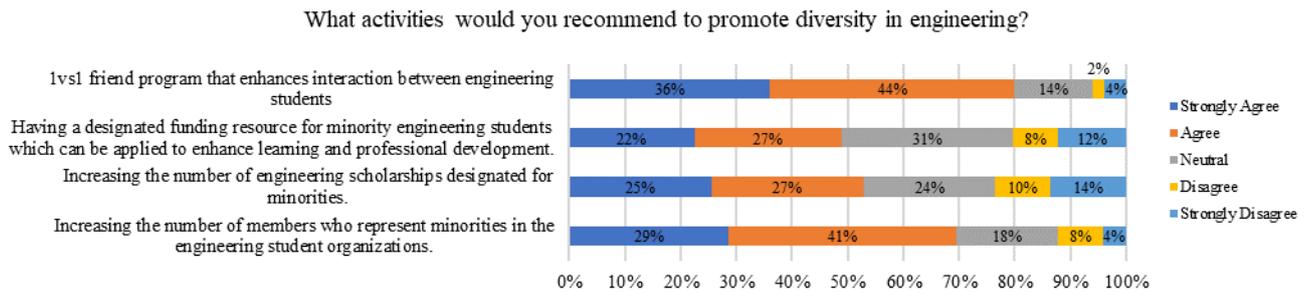


**Figure 16.** Student's perception of the university's diversity activities based on (a) ethnicity and (b) gender.

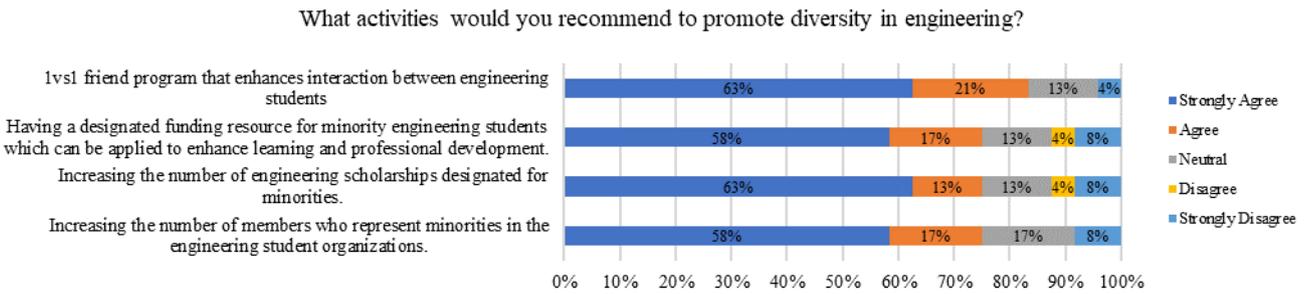
When asked about the challenges encountered in promoting diversity within their individual organizations, a large number of students (35%) that belonged to student organizations identified the lack of diverse members serving as role models as the main challenge in promoting diversity in student organizations. This highlights the critical role of representation in fostering an inclusive environment, which supports the findings of Fan et al. (2021) and Kricorian et al. (2020) [23,34]. Following closely were concerns about insufficient internal diversity (30%), aligning with Ambikairajah et al.'s [35] recommendation that emphasizes the need for diverse perspectives within organizations to enhance creativity and problem solving. Additionally, the respondents (18.3%) indicated a lack of understanding about the benefits of diversity. This emphasizes the importance of educational efforts to promote awareness and inclusivity [35,36]. The need for visible and consistent leadership and inadequate membership to effectively promote diversity further accentuates the multifaceted nature of the challenge of promoting diversity in student organizations. These findings further resonate with the existing literature, highlighting the pressing need for targeted interventions and educational initiatives to address these challenges systematically.

Finally, the engineering students were asked to provide their level of agreement or disagreement with four potential activities that they believed would promote diversity in engineering. Their responses were analyzed and are presented in Figures 17 and 18.

From the analysis, it can be observed that the activity that received the highest level of agreement across the demographic categories considered was implementing a 1-on-1 friend program that enhances interaction between engineering students. The majority of the students indicated agreeing or disagreeing with this as a diversity-promoting activity. While there were agreements for initiatives such as increasing minority representation and allocating scholarships for underrepresented groups, increasing the number of engineering scholarships designated for minorities, and having a designated funding resource for minority engineering students, which can be applied to enhance learning and professional development, non-Caucasians and females indicated a greater agreement for these initiatives promoting diversity in engineering. The disparities are also supported by the  $p$  values from the Mann-Whitney's U test, which are generally less than the significant level (0.05) for these questions (as indicated in Table A7). This trend aligns with past research, such as the findings of Palid et al. [37], emphasizing the efficacy of minority-targeted initiatives in fostering inclusivity and diversity in engineering programs.

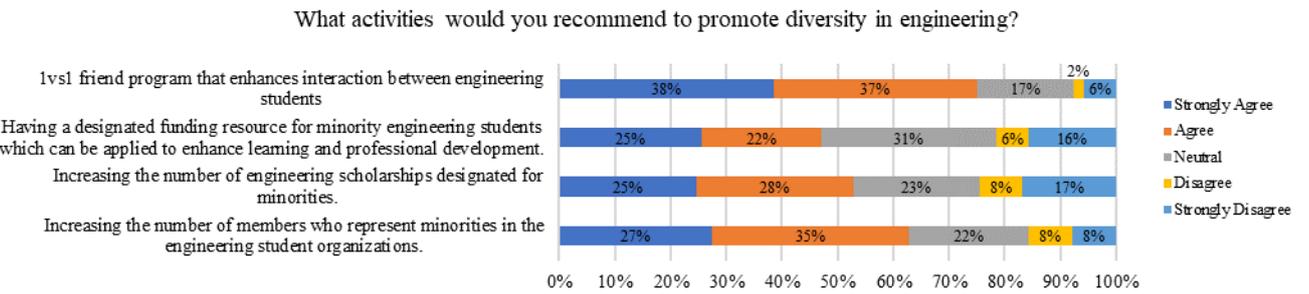


(a)

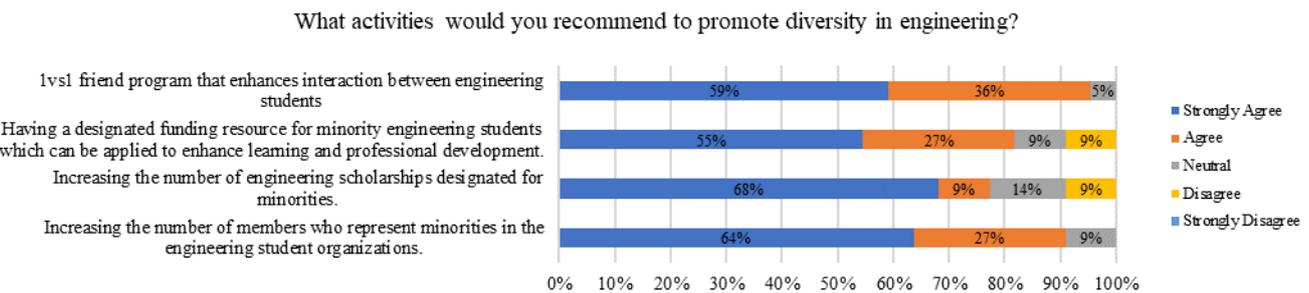


(b)

Figure 17. Ethnicity-based student view on promoting diversity in student organizations for (a) Caucasians and (b) non-Caucasians.



(a)



(b)

Figure 18. Gender-based student view on promoting diversity in student organizations for (a) males and (b) females.

### 3.2.4. Diversity in Engineering Workplace

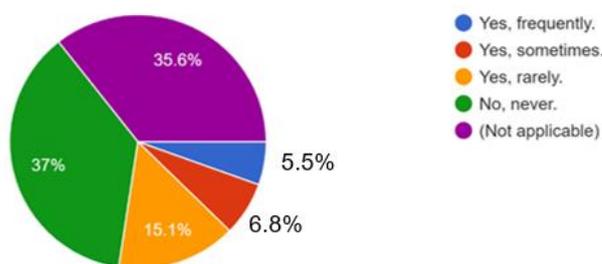
This section of the survey enabled the engineering students to share their perceptions on the issue of diversity in the engineering workplace. The results showed that a majority of the respondents (59%) had no working experience, while 41% had worked either part-time, full-time, or as an intern in an engineering firm or agency. Of the students who had work

experience, a little over half (56%) had worked in companies with more than 100 employees, while one fifth (20%) had worked in companies with a size between 50 and 100 employees, and seven had worked in companies with fewer than 50 employees. Of those companies, the majority (36%) were local or regional companies, followed by profit (28%), international (26%), family-owned (8%), and domestic organizations.

Furthermore, over one third of the engineering students who reported having worked in an engineering firm stated that they had faced discrimination or an uncomfortable learning atmosphere due to their gender, race, or other factors (Figure 19). Non-Caucasians ( $U = 350.5$ ,  $p$ -value = 0.01) and women ( $U = 356.0$ ,  $p$ -value = 0.003) were more likely to be discriminated against in an engineering professional/work environment.

Have you ever been discriminated against or encountered an uncomfortable working environment because of your race, gender, or any other reason?

73 responses

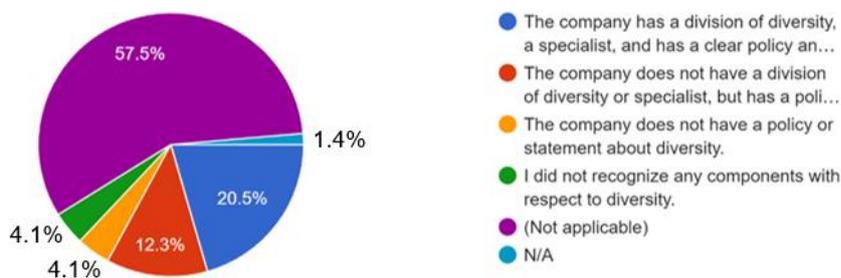


**Figure 19.** A pie chart showing the frequency of discrimination experienced by engineering students in their workplace due to their race, gender, and other reasons.

Additionally, when asked about their impressions regarding diversity at their workplace, about half of the surveyed students reported that their company had a dedicated diversity division, a specialist, and a well-defined policy and statement about diversity. Meanwhile, one third of respondents indicated that their company had a policy or statement about diversity, but no dedicated division or specialist. The others noted that their company lacked any policy about diversity, or that they did not observe any diversity-related components within their workplace (Figure 20).

If you have worked for an engineering company, what is your impression about the company's diversity in the workplace?

73 responses

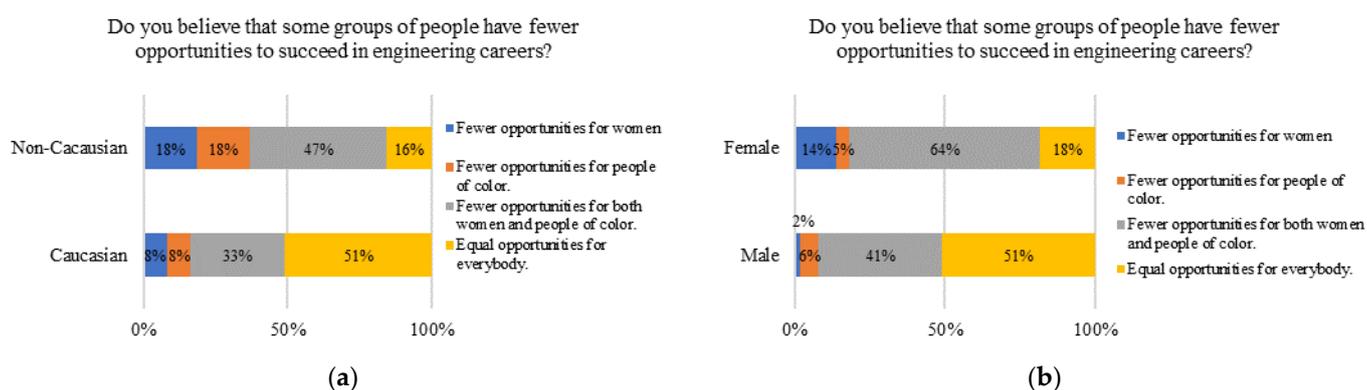


**Figure 20.** A pie chart showing students' perception of workplace diversity policy.

While the majority of the students indicated that the companies they worked for had a clear policy about diversity, the lack of both a diversity policy and components reported by some of the respondents raises concerns about the overall commitment of some engineering workplaces to fostering inclusive environments. Additionally, there is evidence of persistent challenges of discrimination within engineering workplaces, which

highlight the need for industry leaders and employers to do more to create an inclusive working environment for their employees, irrespective of their race or gender.

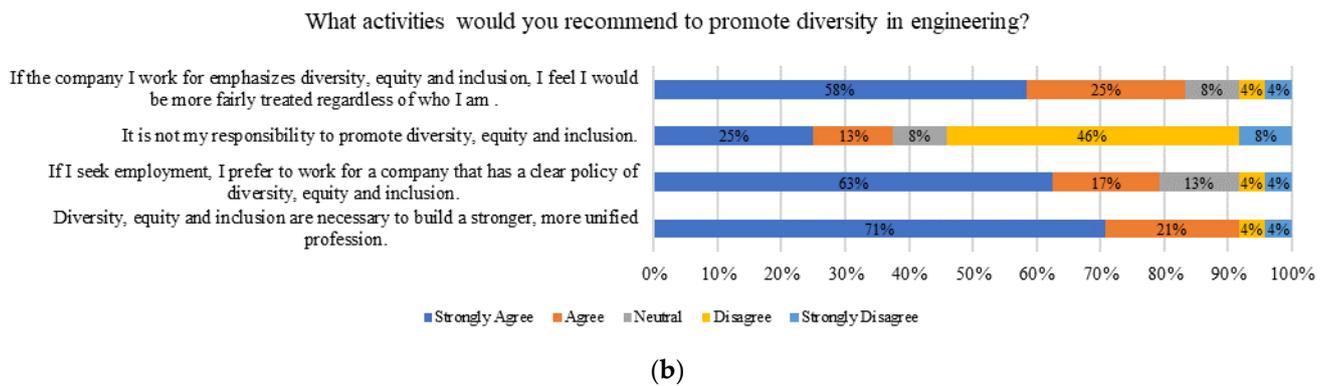
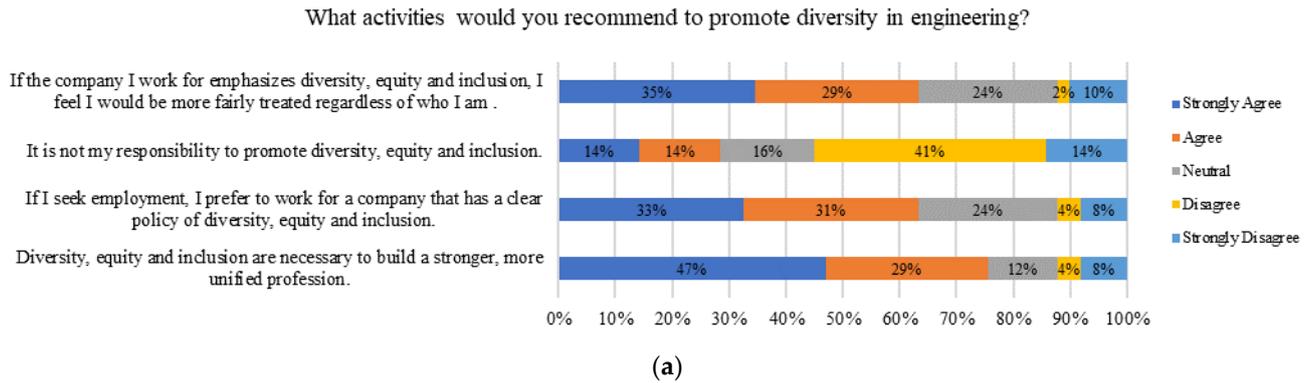
The students were also asked about their opinions regarding the belief that certain groups of people have fewer opportunities to succeed in engineering careers. According to Figure 21, of the 73 respondents, the majority believed that women and people of color face fewer opportunities to succeed in engineering careers. Meanwhile, as represented in Figure 20, non-Caucasians ( $U = 1299.0$ ,  $p$ -value = 0.001) and females ( $U = 763.0$ ,  $p$ -value = 0.007) were more likely to believe that greater hindrance exists for people of color and women to succeed in the engineering sector. This sentiment was echoed by approximately half (49%) of their male and Caucasian counterparts, indicating a shared recognition of existing challenges for underrepresented groups in engineering.



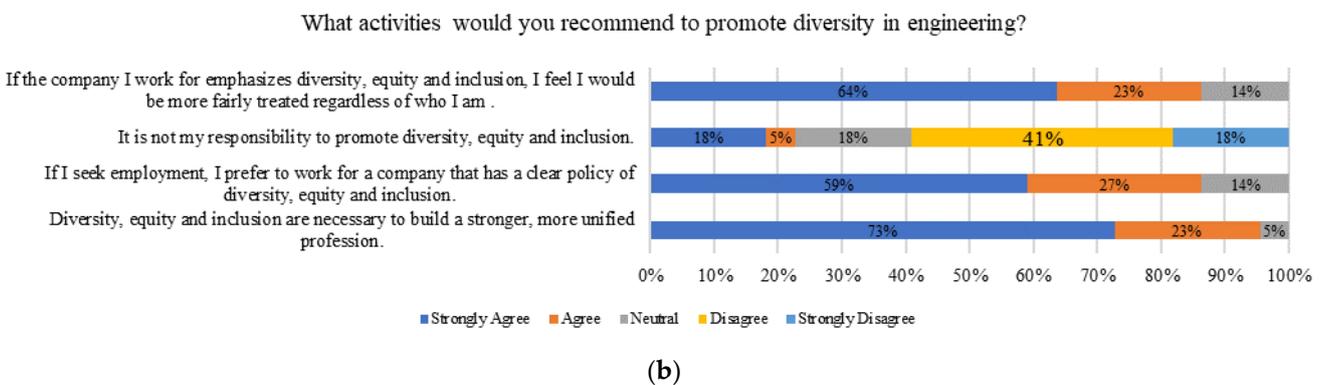
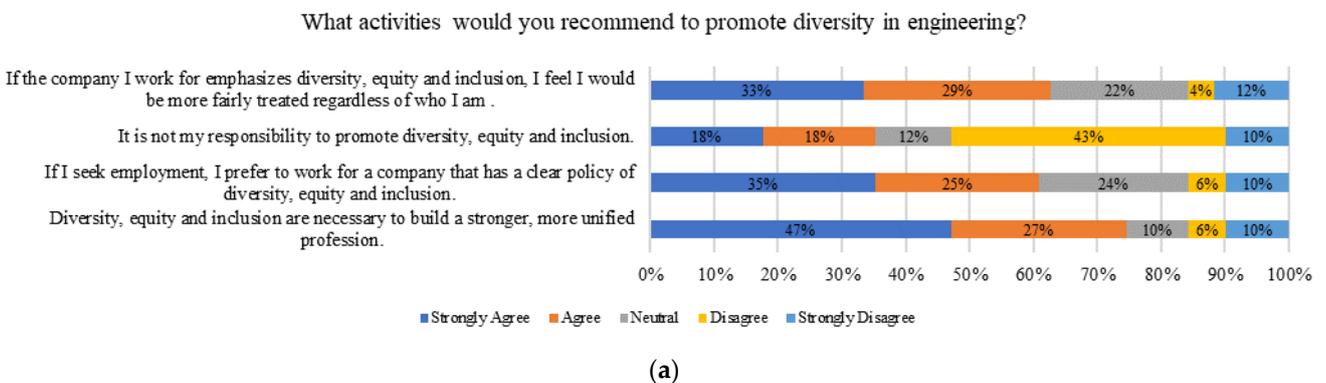
**Figure 21.** A graph showing students' perception of opportunities for minorities to succeed in engineering careers for (a) ethnicity and (b) gender.

These findings align with Salehi et al.'s [31] study, highlighting the anticipation of difficulties for female students in engineering programs and emphasizing the importance of addressing implicit cultural biases through interventions to foster inclusivity and equal opportunities in engineering. This includes teaching and learning strategies that actively challenge these stereotypes and biases during student group work [31].

As part of the survey, the students were also asked to provide their level of agreement or disagreement (strongly agree, agree, neutral, disagree, or strongly disagree) with four statements on promoting diversity in the engineering workplace. Figures 22 and 23 show that the statement "Diversity, equity, and inclusion are necessary to build a stronger, more unified profession" received the highest level of support, followed by the statement "If I seek employment, I prefer to work for a company that has a clear policy of diversity, equity, and inclusion." The statement "If the company I work for emphasizes diversity, equity, and inclusion, I feel I would be treated more fairly regardless of who I am" received moderate support. While the majority disagreed with the statement that it was not their responsibility, there was notable agreement, particularly among the students, with this assertion. This suggests a potential gap in commitments to individual roles in promoting diversity within the profession. Additionally, there existed some preference among students to work in organizations that have a clear policy of DEI and treat all their employees fairly. The belief that building a stronger and unified profession is linked to company emphasis on diversity and inclusion was widely shared, indicating a positive correlation between diversity initiatives and perceived fairness. These findings align with the existing literature [38], emphasizing the importance of DEI in creating a more equitable and unified professional environment. It is noteworthy that, while the majority of the students agreed with these statements of diversity, non-Caucasian (Figure 22b) and female (Figure 23b) engineering students placed a greater emphasis on these initiatives for promoting diversity in the engineering workplace.



**Figure 22.** Students’ perceptions of promoting diversity in engineering workplace for (a) Caucasians and (b) non-Caucasians.



**Figure 23.** Students’ perceptions of promoting diversity in engineering workplace for (a) Male and (b) Female.

### 3.3. Students' Interview Results

To ensure a comprehensive understanding of diversity perceptions, we combined the nuanced qualitative insights gathered through in-person interviews with the structured quantitative analysis from the student survey. This intentional linkage enhances the depth and completeness of our findings, providing a unified understanding of the factors that shape diversity experiences among engineering students.

#### 3.3.1. Interest Driven Engineering Pursuit

When asked about their reasons for choosing engineering as their major, each subject provided unique insights. Subject 1 attributed their interest to a natural curiosity about how things work, combined with a passion for math and a desire to design solutions that could make a positive impact on the world. Subject 2, on the other hand, was inspired by living near an airport and watching planes fly overhead, which sparked their curiosity about engineering. They also appreciated the versatility of the field.

Subject 3 initially pursued a degree in biology but found the pre-med biology track to be too competitive and decided to switch to engineering. They found the team-based environment of engineering to be a more appealing alternative. Subject 4 was always fascinated by engineering and studied its various disciplines before ultimately deciding to specialize in civil engineering. They even pursued a degree in graphic design before returning to school for engineering. Subject 5 had a lifelong passion for building and a natural curiosity about the world. Their father's wood shop sparked their interest, and they found that pursuing engineering allowed them to understand the world in a more systematic and hands-on way. Subject 6 was unsure of what they wanted to do in high school but knew they wanted a degree that would be useful. Their father's career as an engineer served as inspiration for pursuing the field. Overall, it is clear that each subject was driven to pursue engineering based on their unique interests and inspirations.

In essence, the individual stories of these students further highlight the diverse motivations and influences that collectively contribute to some sense of belonging reported by the engineering students in the survey.

#### 3.3.2. Why Diversity and Inclusion Are Important for Engineering?

When asked about the importance of diversity, equity, and inclusion in engineering, each subject provided insightful responses. Subject 1 expressed the importance of ensuring that all individuals who aspire to become engineers have equal access to opportunities without fear of discrimination. However, they also acknowledged that efforts to promote diversity and inclusion can often result in discrimination towards minority groups. They emphasized the importance of equity and merit-based evaluation, rather than focusing solely on a person's inalienable traits.

Subject 2 agreed that diversity is crucial, citing the benefits of diverse teams in providing a range of perspectives and solutions. Subject 3 emphasized the importance of a team-based environment that challenges traditional ways of thinking and problem solving, ultimately leading to more efficient and effective solutions. They also highlighted the value of developing people skills through exposure to diversity.

Subject 4 strongly supported the importance of diversity, recognizing the need for multiple perspectives to tackle complex societal problems. They emphasized the importance of inclusivity and creating an environment that welcomes individuals of all backgrounds.

Subject 5 acknowledged the reality of engineering being predominantly composed of one demographic, and expressed the importance of ensuring that individuals from all backgrounds feel welcomed and valued in the field. They emphasized the importance of representation and creating a diverse and inclusive environment.

Subject 6 recognized the historical barriers that marginalized groups have faced in the field of engineering and expressed the importance of providing equal opportunities to all individuals. They questioned the reasons behind the lack of diversity in the field

and hoped for a future where engineering is accessible and welcoming to individuals of all backgrounds.

In summary, these individual perspectives mirror and reinforce the overarching importance of diversity, equity, and inclusion within the engineering community, expressed by the majority of the students in the analysis of the students' survey.

### 3.3.3. Suggestions for Improving Diversity and Inclusion in Engineering

When asked what could be enacted to promote diversity, equity, and inclusion, various subjects suggested different ways of improving it. Subject 1 emphasized the importance of promoting equal opportunities for all people, regardless of their inalienable traits. They believed that this was the only way to truly promote diversity both in the classroom and in extracurricular activities.

Subject 2 recommended inviting more prospective students of color to campus to get them excited about the opportunity to learn more about engineering. Additionally, they suggested that the College of Engineering consider hiring more diverse faculty members.

Subject 3 suggested using activities, outings, and conferences not directly controlled by professors to promote diversity, equity, and inclusion. They believed that holding events with a professor present but not enforcing activities would allow students to get to know each other without feeling forced.

Subject 4 pointed out that the College of Engineering had a set structure of what they were looking for and that this was apparent in the available class times. They suggested offering more lenience in class scheduling to accommodate those who had trouble due to other circumstances.

Subject 5 commended the professional societies that had made diversity a goal and suggested hosting more cultural events at Shelby to provide opportunities for networking and professionalism outside of the classroom.

Subject 6 pointed out that, if minority groups were prevented from pursuing engineering due to cultural and social pressures, it would be difficult to encourage more minority groups to commit. They suggested diverting more funding to minority professional societies and promoting female faculty with talks, speeches, and events. Additionally, they suggested having female faculty members discuss engineering in front of high school students to encourage more women to pursue engineering without discouraging male students.

Reflecting similar observations from the student survey, the analysis of the student interview response indicates the need for a multifaceted approach to promote diversity, equity, and inclusion in engineering. The students emphasized equal opportunities, representation, and systemic changes. There was also a collective commitment to address societal barriers and cultural pressures and promote targeted initiatives for minority groups. Overall, the students advocated for a comprehensive and intentional strategy to create an inclusive engineering community.

## 4. Conclusions

This case study initiative within the College of Engineering at the University of South Alabama was designed to gauge our engineering students' current perceptions of diversity. It incorporated three key components: textbook evaluations and student surveys featuring 30 questions covering aspects such as the engineering curriculum, student organizations, and the workforce. In-person interviews were further conducted to gather detailed information. The summarized findings, presented below, offer valuable insights for faculty, instructors, and administrators alike.

### 4.1. Textbook

According to the evaluation of three representative civil engineering textbooks, albeit a large quantity, the textbooks lacked culturally and historically accurate portrayals of characters and stories. This deficiency is likely attributable to a lack of diversity among textbook contributors and illustrators. The textbooks provided minimal opportunities for

teachers to promote cultural responsiveness, and students were not sufficiently encouraged to think critically or take action to combat inequity. The review of a “Civil Engineering Materials” textbook found that characters were often identified solely by their profession, with limited details provided. Gender was identified for some characters, but there was no mention of their race. The analysis suggested a leaning toward depicting Caucasian males, Asian females, and characters with no information about their race or ethnicity. Terms related to race, gender, and ethnicity were rarely used in the main text of the textbooks, primarily focusing on technical content related to materials and engineering concepts.

#### *4.2. Students’ Perceptions of Diversity*

##### *4.2.1. General Perception*

The analysis of the responses from our survey revealed a mixed landscape of perceptions of diversity, equity, and inclusion. While the majority of students acknowledged the importance of diversity, disparities in the sense of belonging persisted, particularly based on race and gender. These findings align with the existing literature, emphasizing the impact of representation on students’ experiences. Surprisingly, some students, particularly males and Caucasians, shifted their perception of diversity’s importance after being provided with the definition, indicating a need for clearer education on the topic. Reported instances of discrimination, especially among females, underscore the urgency for addressing biases and fostering a more inclusive environment. The limited awareness of the Office of Diversity, Equity, and Inclusion underscores the need for increased awareness and communication about the office, as well as its role in fostering an inclusive environment.

##### *4.2.2. Diversity in Textbooks and Curriculum*

Our examination of the diversity components in engineering education, as perceived by students, provides valuable insights into its current state and potential improvements for fostering inclusivity within the academic environment. The survey revealed a prevalent belief among the respondents that the engineering curriculum and textbooks lacked explicit content on diversity. The consensus among the engineering students on the importance of inspiring active learning, transparent grading policies, and personal connections with students resonates with studies emphasizing the positive impact of such strategies on student engagement, comprehension, and overall academic success. However, the slight variations in opinion, particularly with females and non-Caucasians placing higher importance on certain diversity-promoting initiatives, highlight the importance of tailored approaches to address diverse preferences in engineering education.

#### *4.3. Students Organization*

Many engineering students were involved in student organizations, including ASCE, ASME, and SWE. While there was a generally positive sentiment regarding the representation of people of color and women in these organizations, there were subtle variations based on gender and ethnicity. Non-Caucasian students expressed a slightly less favorable view, signaling potential underrepresentation concerns and cultural factors influencing their perceptions. A significant portion of respondents were uncertain about the existence of clear diversity policies within their groups. This uncertainty extended to perceptions of the university’s diversity activities, indicating a need for enhanced communication and engagement strategies within student organizations to promote awareness of diversity initiatives.

The challenges in promoting diversity within student organizations are multifaceted, with the lack of diverse role models and insufficient internal diversity being prominent concerns. These findings align with the existing literature emphasizing the critical role of representation in fostering an inclusive environment and the importance of diverse perspectives within organizations for enhanced creativity and problem solving. The consensus on implementing a 1-on-1 friend program highlights the perceived efficacy of personal interactions in enhancing diversity and inclusivity. Additionally, initiatives such as increasing minority representation, allocating scholarships for underrepresented groups, and having

designated funding resources received positive feedback, emphasizing the effectiveness of minority-targeted initiatives.

#### 4.4. Workforce

A significant proportion of the respondents reported instances of discrimination or uncomfortable atmospheres in engineering firms based on gender, race, or other factors. This highlights a persistent challenge within engineering workplaces and underscores the need for industry leaders to prioritize inclusivity and create environments free from bias. While the majority of students indicated that their workplaces had clear diversity policies, the acknowledgment by some respondents of the absence of such policies or components raises concerns about the overall commitment of certain engineering workplaces to fostering inclusive environments. These findings emphasize the need for concerted efforts from employers to establish and communicate robust diversity policies and practices.

Moreover, the students overwhelmingly recognized that women and people of color face fewer opportunities to succeed in engineering careers. This shared recognition aligns with the existing literature emphasizing the importance of addressing implicit cultural biases to foster inclusivity and equal opportunities in engineering education and the workplace. The students' responses on promoting diversity in the engineering workplace revealed a positive correlation between the perceived necessity of DEI and a preference for companies with clear DEI policies. This belief underscores the importance of DEI initiatives in creating equitable and cohesive professional environments. However, the acknowledgment that building a stronger and more unified profession is not an individual responsibility suggests a potential gap in understanding or commitment to personal roles in promoting diversity within the profession.

Drawing insights from the report's findings, educators and administrators should use this information to tailor initiatives aimed at fostering inclusivity and rectifying existing disparities within the engineering community. The diverse perspectives on promoting diversity in engineering underscore the importance of adopting flexible approaches that can accommodate the varied needs and concerns of students.

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**Informed Consent Statement:** Informed consent was obtained from all subjects in the study.

**Data Availability Statement:** Data are contained within the article.

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## Appendix A

**Table A1.** Diversity of Characters Tally or Diversity of Authors Tally [11].

Items	Girl/Woman	Boy/Man	Non-Binary	Total
Middle Eastern				
Asian/Pacific Islander				
Black/African				
Latinx				
Native American				
White/Caucasian				
Racially Ambiguous				
Multiracial				
People with Disabilities				
Animals				
Total				

**Table A2.** Scorecard for Representation [11].

Statements	Very Satisfied (+2)	Satisfied (+1)	Unclear(−1)	Not Satisfied (−2)
Diversity of Characters				
1. The textbook features visually diverse characters, and the characters of color do not all look alike.				
2. There are references to different ethnic and cultural traditions, languages, religions, names, and clothing.				
3. Diverse ethnicities and nationalities are portrayed—not all Asian families are Chinese, not all Latinx families are Mexican, etc.				
4. Diverse family structures (i.e., single parents, adopted or foster children, same-sex parents, other relatives living with the family, etc.) are represented.				
5. Characters with disabilities are represented.				
6. Characters of color are main characters and not just sidekicks.				
7. If there is conflict in the storyline, the characters of color are not mostly considered the problem.				
Accurate Portrayals				
8. Characters of color are not assumed to have low family wealth, low educational attainment, and/or low income.				
9. Gender is not central to the storyline. Female characters are in a variety of roles that could also be filled by a male character.				
10. Social situations and problems are not seen as individual problems but are situated within a societal context.				
11. Characters of diverse cultural backgrounds are not represented stereotypically or presented as foreign or exotic.				
12. Problems faced by people of color or females are not resolved through the benevolent intervention of a white person or male.				
13. Diverse characters are rooted in their own cultures and are not ambiguous				
Total				
Total Representation Score				

**Table A3.** Scorecard for the Social Justice (Modified from [11]).

Statements	Very Satisfied (+2)	Satisfied (+1)	Unclear (-1)	Not Satisfied (-2)
Decolonization/ Power and Privilege				
Centering Multiple Perspectives				
Connect Learning to Real Life & Action				
Total				
Total Representation Score				

**Table A4.** Survey questions for engineering students' perceptions of Ddversity.

Questions	Options
1. How do you agree or disagree with the statement "I feel a sense of belonging to the College of Engineering at the University of South Alabama"?	(A) Strongly Agree; (B) Agree; (C) Neutral; (D) Disagree; (E) Strongly Disagree
2. As an engineering student, when you hear about "diversity in engineering", what is your feeling?	(A) I understand what diversity means in engineering, and it means a lot to engineering. (B) I know what diversity means, but I do not think it means much to engineering. (C) I know a little bit about diversity, and it means a lot to engineering. (D) I know a little bit about diversity, but I do not think it means much to engineering. (E) I do not know anything about diversity in engineering.
3. How do you agree with the statement "Diversity can provide benefits to engineering"?	(A) Strongly Agree; (B) Agree; (C) Neutral; (D) Disagree; (E) Strongly Disagree
4. "Diversity" refers to the presence of differences in any sense such as gender, age, ethnicity, nationality, religion, and sex orientation. After reading the definition and according to your own experience, how important do you think diversity in engineering is?	(A) Very important; (B) Important; (C) Neutral; (D) Not important; (E) Not important at all
5. If you were to give a score about your overall impression about the status of diversity in the University of South Alabama, which score would you give?	Choose from 1 (lowest score) to 10 (highest score).
6. Did you know that the University of South Alabama has the Office of Diversity, Equity, and Inclusion?	(A) Yes; (B) No; (C) Maybe
7. The University of South Alabama has the office of Diversity, Equity, and Inclusion. How much do you know about its function and role?	(A) I know very much about it. (B) I know about it. (C) Neutral (D) I do not know much about it. (E) I have never heard of it.
8. How do you feel about the relevancy of the following description to "diversity in engineering"?	
(1) Engineers are a diverse group of people regardless of gender, age, ethnicity, religion, backgrounds, etc.	
(2) Engineers get along well with colleagues.	
(3) Engineers work with various clients.	(A) Very Relevant; (B) Relevant; (C) Neutral; (D) Not Relevant (E) Not Relevant at all
(4) Engineers provide solutions that satisfy the constraints of cost, performance, environment and society.	
(5) Engineers have equal opportunities to get promoted and receive salary increases.	
(6) Engineers join organizations such as the Society of Women Engineers and the National Society of Black Engineers.	

Table A4. Cont.

Questions	Options
9. Have you recognized any engineering courses that have components of diversity? Examples of components: have a diversity statement in syllabus, learning objective that includes diversity, instructor talks about diversity directly or indirectly.	(A) Yes; (B) No; (C) Maybe
10. You have taken many engineering courses. Generally speaking, how much are components of diversity a part of engineering textbooks used in your courses?	(A) They do not contain any components related to diversity. (B) They contain slight components related to diversity. (C) They contain some components related to diversity. (D) They contain a great deal of components related to diversity.
11. How do you view the importance of the following practices that can promote diversity in an engineering course?	
(1) There is a clear statement about diversity and inclusion in the syllabus.	
(2) The textbook contains more diverse examples (e.g., using an example of an engineer who is part of an underrepresented group).	
(3) Instructors remember your name, personally connect with you, and get to know you well.	
(4) Instructors care about everyone's learning experience and academic performance.	(A) Very important; (B) Important; (C) Neutral; (D) Not important; (E) Not important at all
(5) Instructors have a clear and transparent grading policy for everyone.	
(6) Instructors use some examples related to diversity and inclusion to help students learn technical content.	
(7) Instructors design an assignment related to diversity and inclusion.	
(8) Instructors embrace diversity and invite guest technical speakers who have diverse backgrounds.	
(9) Instructors lead field trips that can broaden students' horizons in not only technical knowledge but also diversity and inclusion.	
(10) Instructors inspire all students to engage in active learning.	
12. Have you ever been discriminated against or encountered an uncomfortable learning environment as an engineering student because of your race, gender, or any other reason?	(A) Yes, frequently. (B) Yes, sometimes. (C) Yes, rarely. (D) No, never.
13. If you encountered an uncomfortable learning environment because of your race, gender, or for other reasons that are not fair to you, what would you do? (Check all that apply)	(A) I will talk about it with instructor. (B) I will talk about it with school authority. (C) I will talk about it with my close friends. (D) I will talk about it with my classmate. (E) I will talk about it with my family. (F) I will do nothing. (G) I am not sure.
14. If you were the instructor, what would you do to promote diversity in engineering?	Open answers.

**Table A5.** Survey questions on student organizations and involvement.

Questions	Options
1. Have you joined any student organization, club, or society?	(A) Yes. (B) No.
2. What student organization(s) are you in?	Open answers.
3. If you are in a student organization, club, or society, what is your role?	(A) Officer (B) Member who is very active (C) Member who is slightly active (D) Member but not involved
4. How do you feel about the representation of people of color in your student organization?	(A) Very good; (B) Good; (C) Neutral; (D) Not Good; (E) Poor
5. How do you feel about the representation of women in your student organization?	(A) Very good; (B) Good; (C) Neutral; (D) Not Good; (E) Poor
6. In your student organization, club, or society, do you have a clear policy or statement that promotes diversity?	(a) Yes. (B) No. (C) Maybe.
7. What are the challenges to making progress on diversity in your organization?	(A) Lack of understanding of the benefits of diversity. (B) Lack of existing diversity within the organization (C) Not enough diverse members to use as role models (D) No visible and consistent leadership
8. How do you feel about the diversity activities that the University of South Alabama has conducted?	(A) I think South has done much. (B) I think South has done some. (C) I think South has not done much. (D) I cannot recall any activities.
9. Imagine that you are a leader. What activities would you recommend to promote diversity in engineering?	
(1) Increasing the number of members who represent minorities in engineering student organizations.	
(2) Increasing the number of engineering scholarships designated for minorities.	(A) Strongly Agree; (B) Agree; (C) Neutral; (D) Disagree;
(3) Having a designated funding resource for minority engineering students which can be applied to enhance learning and professional development.	(E) Strongly Disagree
(4) 1-on-1 friend program that enhances interaction between engineering students	

**Table A6.** Survey questions on diversity in workplace.

Questions	Options
1. Have you worked for an engineering firm or agency, either part-time or full-time, or as an intern?	(A) Yes. (B) No.
2. If you have worked for an engineering company or agency, what is the size of that company?	(A) Less than 50 people; (B) 50 to 100 people; (C) More than 100 people; (D) Not sure.
3. The engineering company or agency you have worked for is: (Check all that apply)	(A) Local or regional; (B) Family-owned; (C) Domestic; (D) International; (E) Profit; (F) Non-profit
4. If you have worked for an engineering company, what is your impression about the company's diversity in the workplace?	(A) The company has a division of diversity, a specialist, and has a clear policy and statement about diversity. (B) The company does not have a division of diversity or specialist, but has a policy or statement about diversity. (C) The company does not have a policy or statement about diversity. (D) I did not recognize any components with respect to diversity.
5. Have you ever been discriminated against or encountered an uncomfortable working environment because of your race, gender, or any other reason?	(A) Yes, frequently. (B) Yes, sometimes. (C) Yes, rarely. (D) No, never.
6. Do you believe that some groups of people have fewer opportunities to succeed in engineering careers?	(A) Fewer opportunities for women. (B) Fewer opportunities for people of color. (C) Fewer opportunities for both women and people of color. (D) Equal opportunities for everybody.
7. How much do you agree with the following statements?	
(1) Diversity, equity, and inclusion are necessary to build a stronger, more unified profession.	
(2) If I seek employment, I prefer to work for a company that has a clear policy of diversity, equity, and inclusion.	(A) Strongly Agree; (B) Agree; (C) Neutral; (D) Disagree;
(3) It is not my responsibility to promote diversity, equity, and inclusion.	(E) Strongly Disagree
(4) If the company I work for emphasizes diversity, equity, and inclusion, I feel I would be more fairly treated regardless of who I am.	

Table A7. Mann–Whitney U Test Statistic (U) and *p* values for gender and ethnicity.

S/N	Mann–Whitney U Test	Ethnicity		Gender	
		Test Statistic (U)	<i>p</i> -Value	Test Statistic (U)	<i>p</i> -Value
1	How do you agree or disagree with the statement “I feel a sense of belonging to the College of Engineering at the University of South Alabama”?	368.0	0.0	503.5	0.458
2	As an engineering student, when you hear about “diversity in engineering”, what is your feeling?	816.0	0.890	677.5	0.052
3	How do you agree with the statement “Diversity can provide benefits to engineering”?	432.0	0.815	608.5	0.548
4	After reading the definition and according to your own experience, how important do you think diversity in engineering is?	706.5	0.110	765.5	0.005
5	If you were to give a score about your overall impression about the status of diversity in the University of South Alabama, which score would you give?	391.0	0.015	641.5	0.310
6	The University of South Alabama has the office of Diversity, Equity, and Inclusion. How much do you know about its function and role?	625.0	0.654	497.5	0.428
7	How do you feel about the relevancy of the following description to “diversity in engineering”? (Engineers are a diverse group of people regardless of gender, age, ethnicity, religion, backgrounds, etc.)	652.5	0.413	597.5	0.637
8	How do you feel about the relevancy of the following description to “diversity in engineering”? (Engineers get along well with colleagues.)	559.5	0.712	554.5	0.935
9	How do you feel about the relevancy of the following description to “diversity in engineering”? (Engineers work with various clients.)	573.0	0.837	578.5	0.805
10	How do you feel about the relevancy of the following description to “diversity in engineering”? (Engineers provide solutions that satisfy the constraints of cost, performance, environment and society.)	596.0	0.915	648.0	0.208
11	How do you feel about the relevancy of the following description to “diversity in engineering”? (Engineers have equal opportunities to get promoted and receive salary increases.)	518.5	0.368	489.0	0.339

Table A7. Cont.

S/N	Mann–Whitney U Test	Ethnicity		Gender	
		Test Statistic (U)	p-Value	Test Statistic (U)	p-Value
12	How do you feel about the relevancy of the following description to “diversity in engineering”? (Engineers join organizations such as the Society of Women Engineers and the National Society of Black Engineers.)	324.0	0.076	698.0	0.074
13	Have you recognized any engineering courses that have components of diversity? Examples of components: have a diversity statement in syllabus, learning objective that includes diversity, instructor talks about diversity directly or indirectly.	364.5	0.004	490.0	0.362
14	You have taken many engineering courses. Generally speaking, how much are components of diversity a part of engineering textbooks used in your courses?	462.0	0.109	636.0	0.330
15	How do you view the importance of the following practices that can promote diversity in an engineering course? (There is a clear statement about diversity and inclusion in the syllabus.)	768.5	0.029	728.0	0.039
16	How do you view the importance of the following practices that can promote diversity in an engineering course? (The textbook contains more diverse examples (e.g., using an example of an engineer who is part of an underrepresented group).)	834.0	0.003	765.5	0.011
17	How do you view the importance of the following practices that can promote diversity in an engineering course? (Instructors remember your name, personally connect with you, and get to know you well.)	680.0	0.186	561.0	1.000
18	How do you view the importance of the following practices that can promote diversity in an engineering course? (Instructors care about everyone’s learning experience and academic performance.)	601.5	0.836	600.0	0.530
19	How do you view the importance of the following practices that can promote diversity in an engineering course? (Instructors have a clear and transparent grading policy for everyone.)	555.5	0.572	591.5	0.588

Table A7. Cont.

S/N	Mann–Whitney U Test	Ethnicity		Gender	
		Test Statistic (U)	p-Value	Test Statistic (U)	p-Value
20	How do you view the importance of the following practices that can promote diversity in an engineering course? (Instructors use some examples related to diversity and inclusion to help students learn technical content.)	683.5	0.245	743.5	0.023
21	How do you view the importance of the following practices that can promote diversity in an engineering course? (Instructors design an assignment related to diversity and inclusion.)	771.5	0.027	802.0	0.003
22	How do you view the importance of the following practices that can promote diversity in an engineering course? (Instructors embrace diversity and invite guest technical speakers who have diverse backgrounds.)	772.0	0.020	785.5	0.004
23	How do you view the importance of the following practices that can promote diversity in an engineering course? (Instructors lead field trips that can broaden students' horizons in not only technical knowledge but also diversity and inclusion.)	812.5	0.005	708.5	0.060
24	How do you view the importance of the following practices that can promote diversity in an engineering course? (Instructors inspire all students to engage in active learning.)	531.5	0.373	603.0	0.499
25	Have you ever been discriminated against or encountered an uncomfortable learning environment as an engineering student because of your race, gender, or any other reason?	787.0	0.007	806.5	0.001
26	If you encountered an uncomfortable learning environment because of your race, gender, or for other reasons that are not fair to you, what would you do? (Check all that apply)	3396.0	0.829	3396.0	0.829
27	How do you feel about the representation of people of color in your student organization?	214.0	0.018	288.5	0.515
28	How do you feel about the representation of women in your advised student organization?	232.5	0.021	279.5	0.330
29	In your student organization, club, or society, do you have a clear policy or statement that promotes diversity?	281.5	0.538	313.5	0.360

Table A7. Cont.

S/N	Mann–Whitney U Test	Ethnicity		Gender	
		Test Statistic (U)	p-Value	Test Statistic (U)	p-Value
30	How do you feel about the diversity activities that the University of South Alabama has conducted?	433.0	0.053	497.5	0.418
31	What activities would you recommend to promote diversity in engineering? (Increasing the number of members who represent minorities in the engineering student organizations.)	732.0	0.076	811.0	0.002
32	What activities would you recommend to promote diversity in engineering? (Increasing the number of engineering scholarships designated for minorities.)	831.0	0.010	841.5	0.002
33	What activities would you recommend to promote diversity in engineering? (Having a designated funding resource for minority engineering students which can be applied to enhance learning and professional development.)	801.5	0.010	786.0	0.005
34	What activities would you recommend to promote diversity in engineering? (1 vs. 1 friend program that enhances interaction between engineering students.)	740.5	0.081	734.5	0.039
35	If you have worked for an engineering company, what is your impression about the company's diversity in the workplace?	114.0	0.237	100.0	0.852
36	Have you ever been discriminated against or encountered an uncomfortable working environment because of your race, gender, or any other reason?	350.5	0.010	356.0	0.003
37	Do you believe that some groups of people have fewer opportunities to succeed in engineering careers?	1299.0	0.001	763.0	0.007
38	How much do you agree with the following statements? (Diversity, equity, and inclusion are necessary to build a stronger, more unified profession.)	739.5	0.050	734.5	0.021
39	How much do you agree with the following statements? (If I seek employment, I prefer to work for a company that has a clear policy of diversity, equity, and inclusion.)	760.0	0.033	747.0	0.019

Table A7. Cont.

S/N	Mann–Whitney U Test	Ethnicity		Gender	
		Test Statistic (U)	p-Value	Test Statistic (U)	p-Value
40	How much do you agree with the following statements? (It is not my responsibility to promote diversity, equity, and inclusion.)	644.5	0.491	497.5	0.427
41	How much do you agree with the following statements? (If the company I work for emphasizes diversity, equity, and inclusion, I feel I would be more fairly treated regardless of who I am.)	749.0	0.046	768.0	0.009

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