Identify Challenges of Inclusive Practices at the Course Level

Dr. Yufang Jin, The University of Texas at San Antonio

Dr. Yu-Fang Jin got her Ph.D. from the University of Central Florida in 2004. After her graduation, she joined the University of Texas at San Antonio (UTSA). Currently, she is a Professor at the Department of Electrical and Computer Engineering at UTSA. Her research interest focus on applications of artificial intelligence, interpretation of deep learning models, and engineering education.

Dr. Yanxia Jia, Arcadia University

Dr. Yanxia Jia is an Associate Professor of Computer Science in the Department of Computer Science and Mathematics at Arcadia University. She earned her doctoral degree in Computer Science from University of Alberta, Canada. Dr. Jia's research interests include data science, machine learning, computer science education and computer networks.

Cate Wengelnik, The University of Texas at San Antonio

Cate Wengelnik has obtained two Masters Degrees in International Higher Education Management and Latin American Business Administration (MBA). She has also received several awards for her contributions on leadership and the effects of high-performance teams. She obtained Certificates in Intercultural Competence, Transcultural Communication and Leadership. She is a certified mediator, has worked overseas in Germany and France and speaks four languages. In her research and teaching background, she focused on leadership, cultural intelligence and high-performance teams, and has completed extensive interdisciplinary research on cultural intelligence in cross-cultural engagements, transnational communication styles and international negotiations. Cate has been working in higher education since 2004 and has served as the Honorary Ombudsman since 2009. Cate currently serves as the Consultant for Academic Innovation advising and counseling faculty of all disciplines on best teaching practices and is a faculty member in the College of Business.

Dr. Frances Matos, University of Texas at San Antonio

Dr. Frances Matos holds a Ph.D. from the University of Illinois Urbana-Champaign. Her area of expertise is pedagogical practices, teacher training and technology enhanced teaching and learning. She is currently part of the Department of Academic Innovation at the University of Texas at San Antonio and is also a faculty member in the University College of UTSA.

Mason Cole Conkel, University of Texas at San Antonio

Mason Conkel is currently a graduate student at the University of Texas at San Antonio. He is pursuing a Ph.D. in Electrical Engineering. His research interests focus on artificial intelligence theory, software, hardware, and education.

Dr. Yan Tang, Embry-Riddle Aeronautical University - Daytona Beach

Dr. Yan Tang is an associate professor of mechanical engineering at Embry-Riddle Aeronautical University in Daytona Beach, Fla. Her current research in engineering education focuses on cognitive load theory, deliberate practice, and effective pedagogical

Jessica Gonzales, The University of Texas at San Antonio

Jessica Gonzales received her MA in Learning, Design, and Technology from the University of Texas at San Antonio (UTSA). She currently works as a Learning Experience Designer with Academic Innovation at UTSA focusing on culture, identity, emergent technologies, and multimodal learning.

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1. Objective and Motivation

In 2018, the National Science and Technology Council Committee on STEM Education released America's strategic plan to lay out a vision for future STEM education with three goals: building strong foundations for STEM literacy, increasing DEI in STEM, and preparing the STEM workforce for the future [1]. Specifically, the second goal, increasing DEI in STEM, is key to achieving the other two goals. Following the guidance of this strategic plan, colleges, and universities have implemented various practices, including recruiting a more diverse faculty and student body for better diversity and inclusion on campus, improving outreach and recruitment to a diverse array of students, providing support services for students, and creating an inclusive campus climate [2]. These practices have improved the diversity in faculty and student recruitment and retention, but they are usually implemented at the institutional level. Specifically, most of these practices focus on establishing a DEI community with a specific program to host a group of students or outreach to a specific community. These programs can be summer bridge programs to broaden college access [3, 4], student retention programs [5], co-curricular resilience programs or campus student learning centers [6, 7], learning communities [8], social belonging interventions [9], and deploying modernized advising practices [10]. Given that faculty interact with students in classrooms on a daily basis, implementing DEI at the course level would create a powerful impact on STEM education and consolidate the achievements of DEI from the institutional level efforts.

Prior research has shown that diverse faculty leadership plays an important role in fostering a DEI culture [11]. Faculty members' curricular decisions and pedagogy, including their interactions with students, can help create more inclusive climates. Research also reveals that the reflection of students in the curriculum helps create a sense of belonging for them and fosters inclusion [11, 12]. Incorporating DEI in classroom teaching needs a good understanding of students' and instructors' perceptions of inclusiveness, such as self-assurance, belonging, empathy, student's voice, trust towards student peers and instructors, as well as faculty readiness and intentionality in creating inclusive activities in their courses. This understanding can help identify the challenges of practicing inclusive STEM pedagogy at the course level.

Establishing such understanding is especially important for post-COVID teaching, given that pandemic-era students experienced significant learning deficits, and students with minority and disadvantaged backgrounds, including secondary and postsecondary, were disproportionally impacted by the pandemic [13-16]. However, very little research has been performed to examine students' perceptions of inclusion and faculty's readiness and intentionality to implement DEI practices in classroom activities. There is an imperative need to establish a good understanding of inclusiveness for both faculty and students to promote the creation of a successful DEI environment in the classroom.

The study aims to identify current challenges to the implementation of inclusive practices in junior-level engineering courses for faculty and students. The problem of identifying challenges of inclusive practices at the course level involves many areas; therefore, as a preliminary endeavor, we focused our attention on students' perception of inclusion and faculty's awareness of DEI concepts and practices, as well as their readiness and intentionality to incorporate DEI practices into teaching.

2. Methods and Results

An inclusive atmosphere in the classroom is created by both faculty and students. In terms of challenges for faculty, we look at the faculty's knowledge of DEI principles and prior experiences with DEI practices. We also attempt to examine the awareness of the integration of DEI practices in the classroom regarding values and norms for classroom engagement and articulation of DEI-related policies such as inclusive statements. Other areas that also require attention are the limitations of time to spend on developing course materials to facilitate DEI in the classroom, and more importantly, access to and eagerness to participate in DEI professional development events and training. A faculty survey was conducted for faculty members who taught in the fall semester of 2022 at the Department of Electrical and Computer Engineering (ECE).

In order to create an inclusive classroom and pedagogy, we as faculty members need to help students develop awareness and understanding of DEI concepts and to provide a variety of opportunities for students to directly interact with the content and with one another in a safe and welcoming classroom environment. An important initial step is to understand students' perception of belonging, self-assurance, and respect for individual identities and perspectives. The deliberate integration of such knowledge via DEI practices is essential to student comfort and trust in their ability to achieve success in the classroom.

A student survey was given to students registered in a junior-level core course, Network Theory, in the Department of ECE at The University of Texas at San Antonio (UTSA), a Hispanic Serving Institute, in the Fall semester of 2022. The selected course has heavy loads of mathematics and physics knowledge while having one prerequisite of Introduction to Electrical and Computer Engineering and two co-requisites including Applied Engineering Analysis and Physics for Scientists and Engineers. The Applied Engineering Analysis course prepares students with knowledge of the analysis of engineering problems using linear algebra and ordinary differential equations (ODE's). The physics course covers knowledge of electricity and magnetism, fundamentals of circuits, electromagnetic induction, and alternative current (AC) circuits. All these topics in the co-requisites are foundations for the Network Theory course. Students registered in the Fall of 2022 took high school AP courses and college mathematical and physical training purely online during the pandemic. Therefore, the student cohort registered in this core course may be a good representation of post-pandemic students with various levels of prior math/physics background. In addition, the recruited student body demonstrates demographic diversity.

The surveyed course consists of two sessions, each of which is supported by an ECE Ph.D. student serving as a teaching assistant. Each session includes a weekly recitation hour to cover key knowledge points and homework problems, as well as three Q&A hours per week. Additionally, both the Department of ECE and the College Student Success Center offer free tutoring services to students taking this course. As this is a core course for all ECE undergraduate students, online resources are available to support student learning.

The instructor has been teaching this course for six years and has conducted various activities to enhance student learning experiences, such as organizing peer tutoring and study groups. The

instructor comes from a minority background and participated in an eight-hour DEI workshop hosted by the institutional learning center during the summer of 2022 to enhance the knowledge of diversity, equity, and inclusion. In the past sixteen years, the instructor has supervised more than 70 undergraduate and graduate researchers with minority backgrounds.

2.1 Student Survey

A student survey was developed with questions about inclusiveness and belonging. The complete survey can be found in Appendix I. Special attention was placed on asking demographic questions to obtain participant information relevant to the study as shown in student survey question 1 (SQ1). The abbreviation SQn denotes the n^{th} question in the student survey. Due to the extensive mathematical knowledge required in the selected core course, we were interested in finding out about the students' experience in previous math courses, where they took these courses, as well as their confidence in math preparation (SQ2, SQ3, and SQ4).

Further, we attempted to ask questions about the student's experience as it relates to their perception of empathy (SQ5), belonging (SQ6), level of trust in others (SQ7), commitment to teamwork (SQ8), communication skills (SQ9), and problem-solving skills (SQ10).

Through questions SQ11 to SQ16, we collected data about students' comfort level with speaking up in the classroom and their perception of being respected, recognized, and listened to. These questions are relevant in determining whether students overall feel supported and included by the instructor. SQ17 was designed to examine the accessibility to technology for students to complete their assignments and coursework.

2.1.1 Assessment Method

For all undergraduate students responding to the survey, demographic information, including whether they are first-generation college students or not, was extracted from our institutional research data. The survey also includes other DEI aspects such as students' mathematical background, accessibility to technology, their perception of their DEI experiences with the course, their comfort level with speaking up in the classroom, and their perception of being respected, recognized, and listened to. Questions SQ5 ~ SQ10 in the student survey were related to students' experiences and skills and were answered with a scale from 1 to 10, with 1 representing the best experiences or expert level of skills and 10 representing the worst experiences or no skills. Student responses to SQ11 to SQ16 were quantified as always =1, often =2, sometimes=3, rarely=4, never=5, unusual or do not recall =6. All quantified measures for the students were analyzed concerning the average and standard deviation.

2.1.2 Results

A total of 85 undergraduate students were registered in the selected junior-level core course, Network Theory, at the end of the Fall of 2022. All students were reached through an online course survey, and 66 (77.6%) students responded to the survey. About 67% of the students were under-represented Hispanics or African Americans, or female students, 33% of the students are first-generation college students, and 17.6% of students were transfer students from other colleges. The data showed diverse student populations responding to the survey.

Table 1. Preparation of mathematical background for the 66 students who responded to questions SQ2 and SQ4 in the survey.		
SQ2: What is your previous experience with Math? Check all that apply:		
I have taken elementary Math	53	80%
I have taken College Algebra	55	83%
I have taken Pre-Calculus	59	89%
I have taken Calculus I	62	94%
I have taken Calculus II	64	97%
I have taken Calculus III	10	15%
SQ4: I feel prepared to transfer my knowledge of Math to this environment.		
Yes	39	59%
No	5	8%
Other	4	6%
Not response	18	27%

Since mathematical knowledge plays a key role in students' performance in this course, we examined the preparation of math for the course as a second consideration of diversity – diversity in academic preparation. As pre-calculus is a prerequisite for Calculus I, and Calculus I is a prerequisite for Calculus II, the percentage of students taking these three courses increases from 89% to 94%, and 97%, respectively. Content of College Algebra such as matrix operations is also used in this course, however, only 83% of students took College Algebra. We are aware that students may obtain such knowledge by taking other introductory engineering courses, but the survey for College Algebra, Pre-calculus, Calculus I, and Calculus II still gives us good insights into how much mathematical backgrounds the group of students has. The survey shows that only 15% of students took Calculus III, which covers a necessary technique, solving ODEs, for the Network Theory course. Further, as shown in Table 1, only 39 (59%) students reported feeling prepared to transfer mathematical knowledge to this environment; on the other hand, 5 (8%) students did not feel prepared, 4 students chose "Other", and the rest of the students did not answer this question. This feeling of under-preparedness may be attributed to the fact that some mathematics and physics concepts are covered in co-requisite courses, rather than in pre-requisite courses.

In response to SQ3 in the survey, 80% of students reported taking some mathematical courses with their home institute while 70% of students reported taking math courses as Advanced Placement courses in high schools, and 38% of students experienced taking math courses in community colleges. This data reveals diverse timing and curricula for taking math courses. The survey showed a very low satisfaction with math preparation before the class, suggesting that reviewing mathematical backgrounds is a necessary teaching component of the class.

In addition to inequality in students' mathematical backgrounds, there also exists an inequity in access to technology. Approximately 67% and 21% of the students reported having access to

technology always or often, respectively. On the other hand, only 9% and 3% of the students had access to technology sometimes and rarely, respectively. Accessibility to technology for students to fulfill their coursework should be considered and arranged at the beginning of the semester to ensure equitable access in the future.

Table 2: Quantified Mean±SD for students' perception of their DEI experiences (scaled from 1-10 with 1 as the best)						
Survey questions	SQ5 Empathy	SQ6 Belonging	SQ7 Trust in others	SQ8 Commitment to teamwork	SQ9 Communication skills	SQ10 Problem-solving skill
Mean ± SD	2.86±1.64	3.93±2.22	3.59±1.75	2.89±1.57	3.15±1.93	3.71±1.94

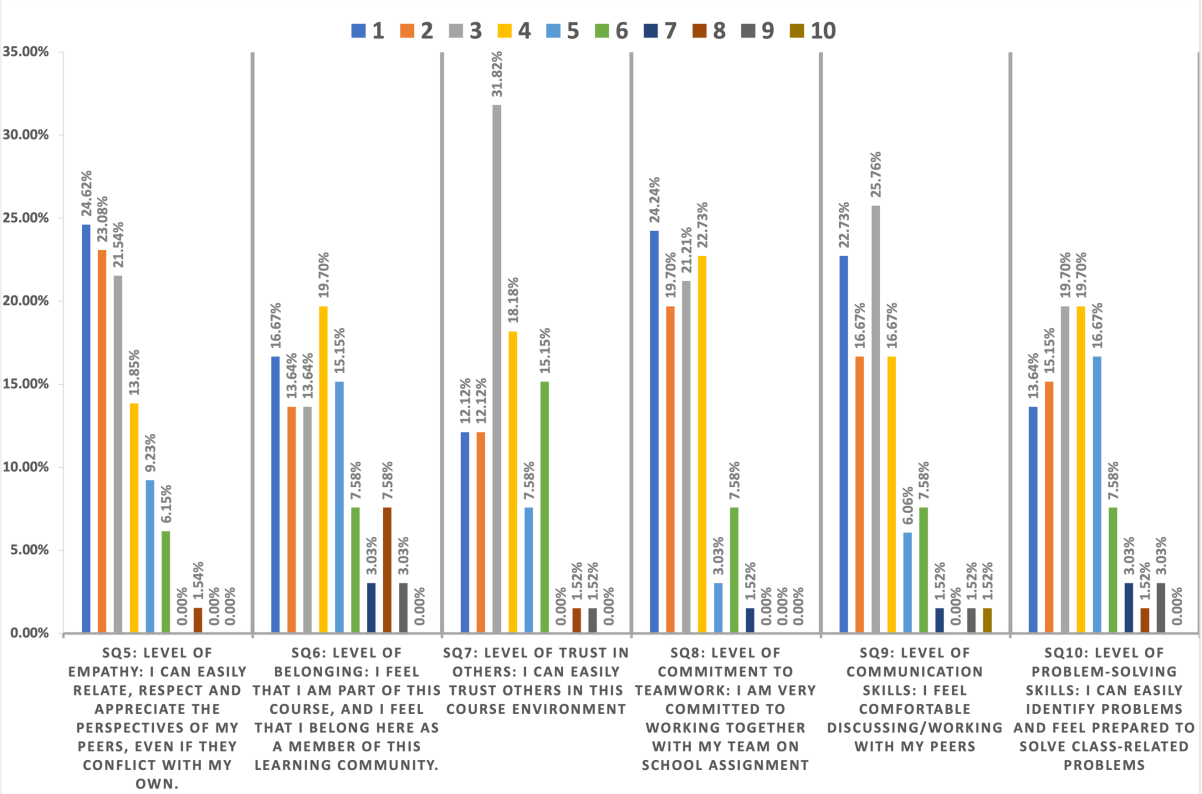

Figure 1. The percentage of students giving scores from 1 (the best score) to 10 (the worst score) for level of empathy (SQ5), belonging (SQ6), trust in others (SQ7), commitment to teamwork (SQ8), communication skill (SQ9), and problem-solving skill (SQ10). For each question, the percentage of students responding to the question with a score of 1 was shown as the leftmost bar, while the percentage of students responding with a score of 10 was shown as the rightmost bar. The response scores are color-coded as shown in the legend on top of the figure. The horizontal coordinate represents the survey questions SQ5 ~ SQ10 and the vertical coordinate represents the percentage of students giving their evaluations to a survey question.

Our survey also showed very interesting results regarding students' perception of their level of empathy, belonging, trust in others, communication skills, and problem-solving skills. The measures of these perceptions are scaled from 1 – 10 with 1 as the best score or expert level skills and 10 as the worst score or no skill, as shown in Table 2. Only 1 student did not respond to SQ5 while all 66 participants answered SQ6 to SQ10.

The mean and standard deviation (Mean ± SD) of levels for empathy, belonging, trust in others, commitment to teamwork, communication skills, and problem-solving skills are listed as 2.86±1.64, 3.92±2.22, 3.59±1.75, 2.89±1.57, 3.15±1.93, and 3.71±1.94, respectively, in Table 2. While students exhibited their highest average levels of empathy (2.86±1.64) and commitment to teamwork (2.89±1.57), they reported relatively high levels of communication skills (3.15±1.93) and relatively low levels of trust in others (3.59±1.75), problem-solving skills (3.71±1.94) and belonging (3.93±2.22) were reported. About 21.21% and 18.18% of students had a low level of belonging and trust in others, respectively, with a score larger or equal to 6 as shown in Figure 1. These scores gave a strong indicator of the need to improve inclusivity in the class with respect to belonging and trust in others.

Table 3: Quantified Mean±SD for students' perception of being respected, recognized and listened to (scaled from 1-6 with 1 as the best).

Survey questions	SQ11 Free to ask question	SQ12 Respected identity	SQ13 Self-confident	SQ14 Listened by instructor	SQ15 Listened by students	SQ16 Acknowledged
Mean ± SD	2.13±1.09	1.68±1.17	2.68±1.05	2.31±0.91	1.89±0.63	2.66±1.08

The Mean±SD of the evaluations from SQ11 to SQ16 was listed in Table 3. Among these responses, 82% of students agreed that their identity is always or often respected and validated (SQ12) as shown in Figure 2. In addition, 84% of students felt always or often listened to by their fellow students in response to SQ15, and 69% of students felt always or often listened to by the instructor in response to SQ14. About 61% of students always or often felt free to ask questions in class when they do not understand, as responses to SQ11. However, only 44% of students agreed that "The class environment helps me to be more self-confident and self-assured about my knowledge in the subject area" in response to SQ13. About 43% of students always or often felt their ability with the course subject is acknowledged by the instructor in response to SQ16. The lower scores for self-confidence and acknowledgment by the instructor are worth noting and need to be addressed at the course level, for example, some team-building activities to encourage and engage students.

The student survey suggested challenges in improving belonging, trust in others, problem-solving skills, and mathematical preparation. In addition, low scores for self-confidence in the class environment and acknowledgment from the instructor provide possible direction for

instructors to create a more inclusive environment in future practices. Addressing these challenges would have a significant impact on students' perception of inclusion and equity.

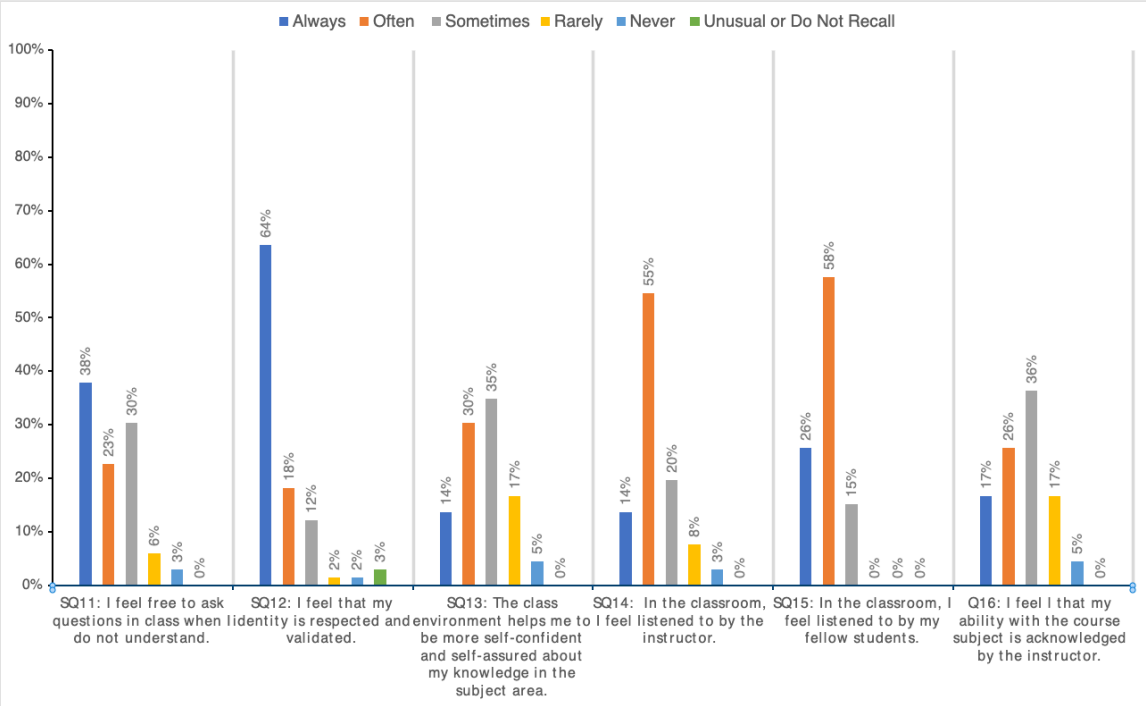

Figure 2. Student perceptions of inclusion of the class and free of speak up for SQ11 ~ SQ16. For each survey question, always, often, sometimes, rarely, never, and unusual or do not recall are color-coded as illustrated in the color legend on top of the figure. The horizontal coordinate represents the survey questions SQ11 ~ SQ 16, and the vertical coordinate represents the percentage of students giving their opinions to a survey question.

2.2 Faculty Survey

With an inclusive mindset, a faculty survey was also developed, which can be found in Appendix II. By asking FQ1 ~ FQ5, we included both full-time and part-time faculty, both graduate-level course instructors and undergraduate-level ones, faculty with different years of teaching experiences and teaching loads, as well as faculty members whose main duties are teaching and/or research. FQn represents the n^{th} question in the faculty survey.

Further, we attempted to ask questions about faculty awareness of DEI concepts and related practices, such as belonging, welcoming classroom environment, inclusivity statement, as well as values and norms for classroom engagement, as can be seen in FQ6 and FQ7.

Lastly, we asked questions about the faculty's readiness and intentionality to implement, DEI practices in their classes (FQ8 to FQ11).

2.2.1 Results from the Faculty Survey

The faculty survey was sent to 20 faculty members at the Department of Electrical and Computer Engineering, and 19 responded to the survey. Among the 19 faculty members, 4 of them have only teaching responsibilities, while 15 faculty members have both research and teaching responsibilities. There were 6 female faculty responding to the survey. The majority of faculty teaches 3 courses per year while teaching loads vary from 1-4 courses per year. In addition, 74% of faculty has more than 6 years of teaching experience, 16% have 3-6 years of teaching experience, and 11% have less than 3 years of teaching experience.

We attempted to study the faculty's level of awareness of DEI topics including belonging, a welcoming classroom environment, inclusive statements, and values and norms for classroom engagement, as shown in Figure 3. Although 95% of faculty knew the concept of DEI in teaching, as shown in response to FQ6, Figure 4 reveals that approximately 37% and 31% of faculty were not aware of the concepts of belonging and inclusive statement for classroom practices, respectively, in response to FQ7.

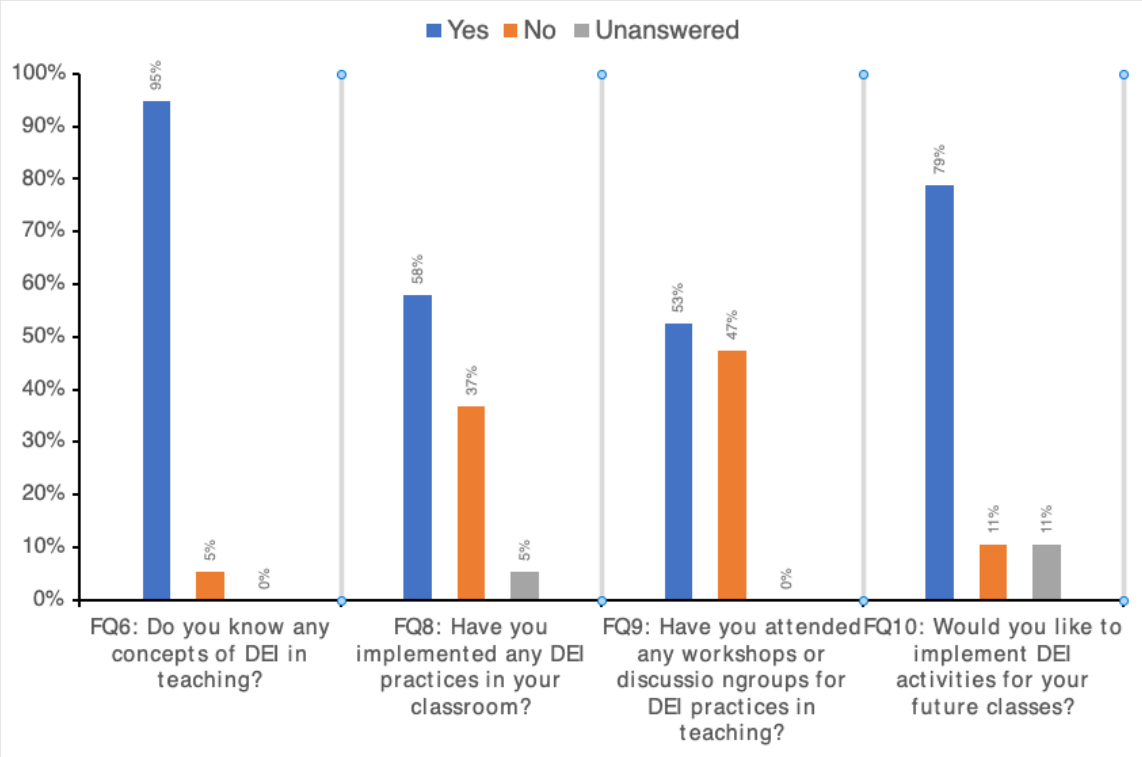

Figure 3. Faculty members' responses to readiness and intentionality to implement DEI practices at the course-level. The response of "Yes", "No", and "Unanswered" are color-coded as illustrated in the color legend on top of the figure.

It's also shown, in Figure 3, that only 58% of faculty reported having implemented DEI practices in their classroom (FQ8), and 53% of faculty reported attending workshops or discussion groups for DEI practices in teaching (FQ9). These findings suggest a relatively low rate of actual actions taken to integrate DEI practices at the course level. We also examined the faculty members' intentionality to implement DEI practices in the classroom in FQ10 and found that

approximately 79% of faculty expressed a desire to incorporate DEI practices in their teaching in the future.

Notably, in response to this survey question, 63% of faculty indicated that they would expect to spend less than 3 hours implementing DEI practices, 26% expected to spend 3-6 hours, 5% expected to spend 6-12 hours, and 5% were uncertain about the exact time commitment required. The analysis of the faculty survey results suggests that, despite faculty members' awareness of the DEI concepts and general willingness to implement DEI activities in the classroom, we do not observe strong evidence of concrete actions taken in DEI training and actual DEI practices in the classroom, as well as a time commitment beyond three hours to prepare and carry out DEI practices.

We have observed that faculty members who participated in DEI workshops are slightly more inclined to incorporate DEI activities in their courses (8 out of 10) than those who did not participate in such workshops (7 out of 9). Additionally, faculty members who attended the workshops showed a greater willingness to invest more time in implementing DEI practices in their courses. However, we must acknowledge that the small sample size limits the statistical power to draw any further conclusions.

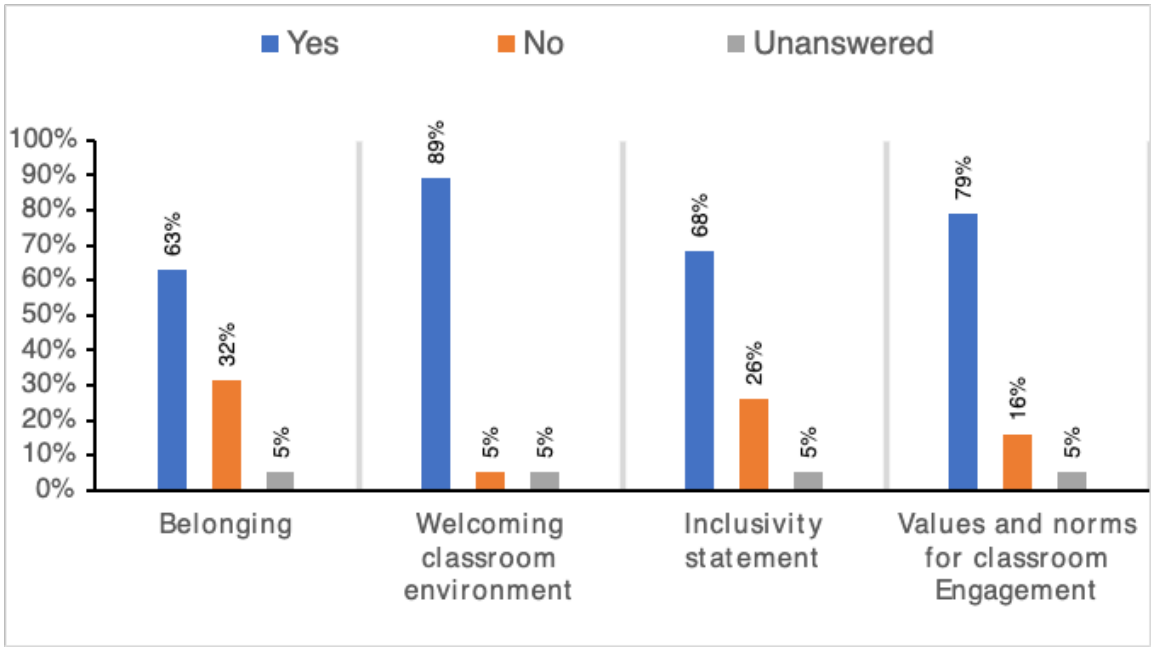

Figure 4. Faculty's perception of belonging, a welcoming classroom environment, inclusive statements, and values and norms for classroom engagement (FQ7). The response of "Yes", "No", and "Unanswered" are color-coded as illustrated in the color legend on top of the figure. The percentage of faculty giving an opinion is represented in the vertical coordinate.

3. Conclusion

This study aims to identify the challenges of inclusive practices at the course level.

We propose to address this issue from two perspectives: students and faculty. For students, we examine their perception of inclusion in the classroom, and for faculty, we study their awareness of essential DEI concepts and their readiness and intentionality for implementing inclusive practice in their classes.

The student survey was distributed to students in a junior-level core course in the Department of Electrical and Computer Engineering hosted in an HSI. The nature of the course requires heavy mathematics and physics background. The recruited students demonstrated diverse demographics including ethnicity and status of first-generation college students. Diversity is also observed in students' various levels of preparedness in mathematical backgrounds. Our survey results showed students' under-preparation in mathematics and low self-confidence in transferring mathematical knowledge into the course subject. It's reported that disparity of preparation in math background can significantly impact student learning [17, 18], which is a form of inequity. In addition, a small number of recruited students did have difficulties accessing technology for their coursework, which may affect their performance due to this inequity.

In terms of students' perception of inclusion, our survey showed that most of the students had a high level of empathy, commitment to teamwork, and communication skills; however, their levels of belonging, trust in others, and problem-solving skills are relatively low. These results provide potential directions for teaching practices for instructors to improve DEI at a course level.

Our faculty survey demonstrated that 95% of the recruited faculty knew the concept of DEI in teaching, while their understanding of detailed DEI concepts on belonging and inclusive statements is still lacking. This might be attributed to a lack of training on DEI practices, since approximately half of the faculty had not attended any workshops or discussion groups for DEI practices or implemented DEI practices in their classroom. We asked for the participation of training in the survey, however, transferring the concepts obtained from the workshops or discussion groups to the expertise of implementing DEI practices is not guaranteed. Furthermore, despite that 79% of surveyed faculty would like to implement DEI activities in future classes, only 31% expect to spend more than 3 hours doing so in response to FQ11. This current status of faculty's readiness and intentionality to implement DEI practices at the course level presents challenges in promoting DEI practices at the course level. Therefore, institutional-level efforts might be considered to enhance the awareness of the importance of DEI practice at the course level and to motivate faculty to implement these practices. Currently, the home institution where the survey was conducted provides a $1,000 incentive for faculty members to attend an 8-hour hands-on short course to obtain training on designing and implementing DEI activities in their courses. Our result is consistent with the finding of other research that there is an acknowledgment of the need for increased DEI efforts, but limited resources have been allocated for faculty to develop and execute DEI practices [19]. More support at all levels should be encouraged to address the needs.

There are limitations to our study. The survey only includes 66 undergraduate students registered in a core course in the Fall of 2022. This study can be further improved by recruiting students from multiple courses, departments, or institutions. Also, bias may exist in the selection of the course and regional effects of the home institutes. Further studies might also be needed to

examine the effects of graduate teaching assistants on students' perceptions of DEI since graduate teaching assistants also have regular interactions with students.

4. Acknowledgment

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5. Appendices

5.1 Appendix I

The student survey includes 17 questions listed as follows.

SQ1: Please indicate how you identify yourself.
- ☐ Male
- ☐ Female
- ☐ Non-binary
- ☐ Other
- ☐ Prefer not to answer

SQ2: What is your previous experience with Math? Check all that apply:
- ☐ I have taken elementary Math
- ☐ I have taken College Algebra
- ☐ I have taken Pre-Calculus
- ☐ I have taken Calculus I
- ☐ I have taken Calculus II
- ☐ I have taken Calculus III

SQ3: Where did you take the math classes? Check all that apply
- ☐ Advanced placement in high school
- ☐ At your current institution
- ☐ At a community college
- ☐ At another university
- ☐ I placed out of Math

SQ4: I feel prepared to transfer my knowledge of Math to this environment
- ☐ Yes
- ☐ No
- ☐ Other

SQ5: Student perception of empathy: I can easily relate to, respect, and appreciate the perspectives of my peers, even if they conflict with my own.

SQ6: Student perception of belonging: I feel that I am part of this course, and I feel that I belong here as a member of this learning community.

SQ7: Level of trust: I can easily trust others in this course environment.

SQ8: Level of Commitment to teamwork: I am very committed to working together with my team on school assignments.

SQ9: Level of communication skills: I feel comfortable discussing/working with my peers.

SQ10: Level of problem-solving skills: I can easily identify problems and feel prepared to solve class-related problems.
SQ11: I feel free to ask questions in class when I do not understand.
SQ12: I feel that my identity is respected and validated.
SQ13: The class environment helps me to be more self-confident and self-assured about my knowledge in the subject area.
SQ14: In the classroom, I feel listened to by the instructor
SQ15: In the classroom, I feel listened to by my fellow students.
SQ16: I feel l that my ability with the course subject is acknowledged by the instructor.
SQ17: Do you have access to the technology you need to complete your coursework?

4.2 Appendix II

The complete list of questions in the faculty survey.

FQ1: Are you a faculty member with__ (check all that apply)
- ☐ Research duties
- ☐ Teaching duties
- ☐ Both

FQ2: Did you teach a graduate or an undergraduate course in Fall 2022?
- ☐ Graduate
- ☐ Undergraduate
- ☐ Both

FQ3: How many courses do you teach every year ?
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 6+

FQ4: Are you a full-time or part-time instructor?
- ☐ Full-time
- ☐ Part-time

FQ5: How many years of teaching experience do you have?
- ☐ <3
- ☐ 3-6
- ☐ 6-12
- ☐ 12+

FQ6: Do you know any concepts of DEI in teaching?
- ☐ Yes
- ☐ No

FQ7: Are you aware of any of the following DEI concepts/practices in the classroom?
Belonging
- ☐ Yes
- ☐ No

Welcoming classroom environment

- ☐ Yes
- ☐ No

Inclusivity Statement

- ☐ Yes
- ☐ No

Values and norms for classroom engagement

- ☐ Yes
- ☐ No

FQ8: Have you implemented any DEI practices in your classroom?

- ☐ Yes
- ☐ No

FQ9: Have you attended any workshops or discussion groups for DEI practices in teaching?

- ☐ Yes
- ☐ No

FQ10: Would you like to implement DEI activities for your future classes?

- ☐ Yes
- ☐ No

FQ11: If you would like to implement DEI practices in your classroom, how many hours approximately would you expect to spend on doing that?

- ☐ <3
- ☐ 3-6
- ☐ 6-12
- ☐ 12+

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