

Learning the Impact of Diversity, Equity, and Inclusion Modules in an Undergraduate Electrical Engineering Classroom

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Abstract:

In this paper, we present the design and implementation of a set of diversity, equity, and inclusion (DEI) based modules, created to be deployed in an introductory computing course offered to first year students in our program. Our objective is to ensure that engineering undergraduate students, who are not historically exposed to DEI content within the engineering curriculum, are introduced to these important topics in the context of their technical coursework and that they understand the relevance of DEI to their careers. We created 6 modules that cover a wide range of topics including untold stories throughout the history of computing and algorithms, identity and intersectionality in engineering, designs from engineering that have high societal impact, the LGBTQ+ experience in engineering, engineering and mental health, and cultural diversity within engineering. Each module gives a brief overview of the topic, followed by an associated assignment. We made all of these modules available to the students in the course and told them to choose one to complete. Each student engaged with their selected module in four specific ways: (1) watching a relevant video; (2) reading and annotating a provided article; (3) responding in a written reflection to a set of specific prompts relevant to the module; and (4) conducting an interview with a peer or community member using a list of suggested questions about the module's contents. Afterwards, we required students to communicate what they learned through completing and submitting a graded final deliverable. This deliverable could be a video, slide presentation, a written op-ed piece, or a piece of art about the work they completed in the module. We evaluated the content of the modules through a survey that assessed the students' interest in the modules and determined the utility of the modules in the context of the study of computing. Based on the feedback of these surveys along with feedback from the instructors of the courses, we will further develop and improve the structure and content of these modules and expand their reach to additional engineering courses and disciplines.

Motivation for Study:

Engineering colleges and universities across the country are now beginning to acknowledge and support the demand for diversity and inclusion by implementing programs to recruit and retain students from diverse and underrepresented backgrounds [1]. The shifts in engineering education that introduce these issues to engineering students are also beginning to motivate novel forms of pedagogy. In their paper, *Achieving STEM diversity: Fix the Classrooms*, Handelsman *et al.* argue that recruiting engineering students from underrepresented backgrounds is not sufficient to transform the makeup of our student bodies [2]. To ensure that we **retain** these students, engineering faculty must focus their efforts on effective classroom practices that recognize the diversity in educational and cultural backgrounds, and energize, motivate, and engage these students. Many different instructional interventions have been implemented in different engineering classrooms that expose students to DEI-themed topics. For instance, Benson *et al.* [3] incorporated diversity and inclusion activities, including one that helps students to get to know each other and another that exposes students to successful role models from diverse backgrounds in their lower-division computing course. Their motivation for bringing these everyday activities into the classroom was to encourage regular discussions of these topics

among students and to increase student awareness of issues students from underrepresented populations face in engineering learning spaces. Having these discussions during lecture or in the context of the course can also address the issue of stereotype threat [4] faced by certain cultural student groups, which is known to impact student success. Further, intentionally incorporating these exercises into the course design communicates to students a strong desire to create an inclusive learning environment. Walden et al. recommended based on research that for creating an inclusive atmosphere for diversity and equity within engineering education, it is important to have a positive academic culture for people from excluded identity groups [5]. Additionally, diversity, equity and inclusion within engineering education has several components. As some examples, engineering courses and curricula can integrate anti-racism by presenting contributions from Black innovators and theorists and by changing the language we use (e.g., using the word “minoritized” to highlight the fact that it is a system that has caused people from particular races and ethnicities to be historically excluded from engineering) [6]. Intel addresses the gender gap issue in engineering, for instance, through camps in the U.S. middle school inspiring girls to become technology creators and innovators and through connecting more women to the Internet and to basic technology skills so they can access information and new economic and social opportunities [7]. It is important to address each diversity, equity, and inclusion issue directly and individually to give the best chance at leveling the opportunities for everyone.

The Climate Survey Report for a survey conducted in 2021 and published in 2022 in our School of Engineering calls on members to “Seek out opportunities ... to educate yourself about the experiences of people with backgrounds and experiences different from your own, particularly groups who are marginalized in engineering,” and for faculty to “Bring diverse perspectives to class through the examples you use, the practicing engineers and projects you highlight and by allowing students some flexibility in helping you identify some of these examples and topics for real-life applications of course material” [8]. This project was designed to act on these recommendations and continue the general trend across the nation of successfully introducing DEI topics to engineering students.

Research Questions:

The following were the research questions that guided our research and the implementation of this project.

1. What are the various aspects of DEI that are relevant in the context of computing and engineering coursework, and how should we design curricula for this DEI-themed instruction?
2. What are our students’ perceptions of DEI-themed topics in the context of an introductory computing course?

Design and Implementation:

All the electrical and computer engineering students at our university take an Introduction to Computing course in their first year. Infusing DEI elements into the design of this first-year course would therefore inform and shape our students from the outset. This work would build on prior work conducted by one of the authors and her teaching assistant, to rewrite the narrative of all the programming assignments to include DEI themes [9]. While the objective of each of the

programming assignments was to teach programming concepts such as branching, sorting, subroutines, data structures, and interrupts, the narrative of each assignment described scenarios addressing diversity/inclusion issues. For instance, the assignment that covered sorting algorithms was about sorting historical dates pertaining to engineering (including dates when faculty from underrepresented populations were hired), and the assignment that covered data structures was about navigating the different resources available to students on our campus such as the Gender/Sexuality Center.

In the pilot phase of the project, we developed six modules, each of which featured one aspect of DEI and its impact on the engineering profession. The topics and objectives of the six modules are listed in Table 1. Students were required to select one module and complete all the assignments in that module. This was titled *The Impact of DEI on computing/engineering project* and worth 5% of the final grade.

Topic	Objective
Cultural Diversity within Engineering	Recognizing the challenges that people from each and every cultural group face will help you build awareness of the community for which you will build engineering solutions in your future careers. Seeing how people from diverse cultures approach problem solving can help you leverage your peers' cultural backgrounds and give you completely new perspectives on your own career aspirations.
Engineering and Mental Health	Managing stress effectively and prioritizing mental health are both essential for academic and career success. In this module students will learn about the diverse factors that affect their overall well-being , and become aware of the resources available.
Engineering Solutions with High Societal Impact	Learning about engineering solutions with high societal impact will help the student understand the potential they have to positively impact the world as they develop their knowledge and skills as an engineer, particularly in the context of tackling problems concerning equity.
The History of Computing	There are several contributions to the field of engineering made by people of diverse backgrounds that go overlooked in the numerous narratives of its history. In this module, students are encouraged to explore some of the untold stories.
Identity and Intersectionality	Learning about how gender identity/race/class/sexual

within Engineering	identity/disability factors into an engineer's experience will build the student's awareness for the struggles that people with different identities face, develop empathy for these groups of people and help to eliminate stereotypes that can threaten the overall student learning experience.
LGBTQ+ Experiences within the Engineering Community	Meaningfully engaging with and learning about people with different genders and sexualities in the engineering community will help the student build awareness and develop empathy for engineering students regardless of gender and sexual orientation and also help address stereotypes that can threaten LGBTQ+ student learning experiences.

Table 1: Module topics and objectives

Each module was designed to have the structure shown in Table 2. Each component in the module was carefully modeled after Bloom's Taxonomy to ensure that students engage in higher cognitive levels (Create) by building up from lower cognitive levels (Understand).

Understand	
Description: Provide students with a few articles and some video/audio resources describing the topic.	Student Activity: Read at least one of the articles and the video/audio resources to understand the topic in greater detail.
Analyze	
Description: The students reflect on their reading and audio/video assignment.	Student activity: Write a reflective summary describing what they learned from their chosen resources.
Engage	

<p>Description: Find an individual that has experience with the topic. It can be an expert or someone who has had a personal experience, or someone who is affected by the topic being discussed.</p>	<p>Student activity: Prepare and carry out an interview with the individual.</p>
<p>Create</p>	
<p>Description: Students must present a final deliverable that synthesizes all the learning they have acquired.</p>	<p>Student activity: Students must prepare one of the following products that communicates what they learned:</p> <ol style="list-style-type: none"> 1. A slide presentation 2. A reworded lab narrative from the course to incorporate their selected DEI theme. 3. An op-ed piece 4. A piece of art: a drawing, painting, piece of music, video, or poem

Table 2: Module Structure

Findings:

In this section we have reported student feedback on this project and their experiences completing the deliverables. In total 148 students completed the project. The majority of these students come from Asian and Caucasian ethnicities while there are also a minority of Hispanic and African American students. The projects were often titled based on the overall project name, “Impact of DEI on engineering” and incorporated the specific module title names. The percentage of students who completed each module is listed in Table 3. As is clear from these data, the majority of the students selected the Engineering and Mental Health module. We believe that one of the main motivators for students to select this module was that they were required to interview themselves rather than another individual, which logistically must have been much easier to manage.

Module Topic	Percentage of students
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Cultural Diversity within engineering	10
Engineering and Mental Health	60
Engineering Solutions with High Societal Impact	13
The History of Computing - The Untold Stories	15
Identity and Intersectionality within engineering	2
LGBTQ+ experiences within the engineering community	< 1

Table 3: Module selections

In Figure 1 we have included a poem written by a student who chose *The History of Computing - The Untold Stories* module, and an art piece drawn by a student who chose *The Cultural Diversity within Engineering* module.

Looking Through the Eyes of Diversity
 Inspired by Katherine Johnson

Degrading, shameful, undeserving.
 The words burn through me.
 Overlooked, excluded, forgotten.
 To them, I am unworthy.

But in my mind, rockets soar through the sky and
 into space.
 Computing for Nasa, but to little avail.
 Separated by a wall of ignorance.
 Only my equations slip through the cracks, my name
 still unknown.

Stories untold, ideas lost.
 They are blind.
 Only the generations to come would know my worth.
 Guided by my hand, trajectories are traced
 through the stars and imprinted on the moon.

A living computer, molding the future to come.
 Struggling to break down the wall of inequity, in the
 shadows of false superiority, we achieved despite the hate.
 How different would the world be,
 if seen through the eyes of diversity?

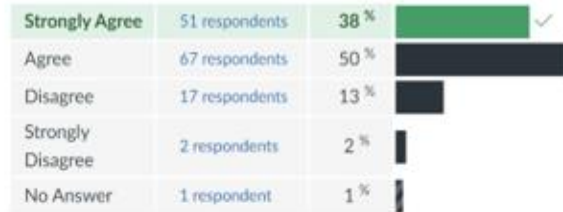


Figure 1: Examples of student products from two different modules.

We administered a short survey at the end of the semester to gauge the impact of this project on the students’ understanding of DEI-themed topics in the context of the technical content of this introductory computing course. The responses to some of the questions are shown in Figure 2

below.

The Impact of DEI on Computing and Engineering
Project is relevant to my career aspirations



The Impact of DEI on Computing and Engineering
Project is useful for undergraduates in electrical and
computer engineering to know



The Impact of DEI on Computing and Engineering
Project belongs in this course.



Figure 2: Survey responses

From these student responses it is evident that the majority of the students believed that this project contributed to their understanding of DEI-themed topics in the context of computing. 95% of the students agreed that this project was useful to them, but fewer (88%) students agreed that this project was relevant to their career aspirations, which can be explained by the fact that these were first year students and have not fully grasped the impact their education can have on their future careers. It was heartening to see that 75% of the students agreed or strongly agreed that this project belongs in this first-year computing course.

Some of the student comments from the survey have been listed below. The recurring message in

these comments was that students engaged with this project deeply, and the materials encouraged them to reflect on how the various DEI-themed topics are relevant to their engineering education.

“I chose the module about cultural diversity because I am an international student. I think this allowed me to learn more about diversity, particularly in STEM majors which is not talked about so often.”

“It was good and made me think about diversity in engineering more and become more aware of the problems some people face. It wasn't overly hard and I feel like I learned a lot.”

“I chose the history of computing module because I read a book about the ENIAC a while ago, so I wanted an opportunity to continue learning about the history and development of computing. It turned out to be less about the development of computing itself and more of understanding the diversity surrounding it, but it was interesting since I got to learn about a ton of scientists and inventions that most never learned about.”

“Personally, I believe that the Impact of DEI in engineering is incredibly important. The diversity, equity, and inclusion of the major is what will motivate people of all backgrounds to consider the major. It is important to make our major an inclusive one, to make students feel heard and welcomed, and to provide the materials needed for this to happen to leaders who can enforce the change.”

“I chose the Cultural Diversity module. I chose this module because I am invested in creating diversity and representing my culture in engineering. When choosing a major, the thing that inspired me was the lack of Hispanics and women in the field, and I think this project allowed me to use my voice in order to represent the importance of cultural diversity for minority students such as myself.”

“I chose the mental health module because it felt the most topical to my current position as a student. I quite enjoyed the article I chose as well, as it had some very interesting data pertaining to the mental health issues faced by different demographics within engineering. I particularly enjoyed making my art piece for the "product".”

“From my perspective, the Impact of DEI on Computing was a crucial project, because it enabled me to contextualize my academics and coursework within the professional role of engineering. The inquiry into the impact of diversity, equality, and inclusivity on engineering was a formative one, as it functioned as a reaffirmation of the positive, inspiring, and engaging culture that we ideally desire in computing.”

“I believed that the DEI project was very helpful in exploring the things that come with engineering. And that learning this has made me reevaluate myself as well, allowing me to feel better and gain more aspirations.”

“At first, when the class was introduced with the concept of the Impact of DEI on Computing and Engineering, I was a bit hesitant to explore this topic because I have never heard of an engineering project of such nature before. However, as I was doing the project, I learnt that this

is exact why this project is needed. I now believe that it is important for engineering students to explore something beyond the technical content covered in their engineering classes such as finding ways to promote inclusivity and equity within the engineering culture.”

The various responses from the students indicate that many chose their respective topic due to some connection to their own lives. Students show that incorporating such DEI material into their technical courses allowed them to explore engineering in a way that they otherwise would not have gotten to.

Future work:

The next phase of our project is threefold:

1. Include a collaborative component to the project in this first-year course, so that assigned teams of 2-3 students work together on one module. To ensure that all team members are in agreement with the selection of the topic, request each team to elaborate on their reasons for choosing the topic. This may also address the reasons why certain topics are more popular than others.
2. Conduct a demographic analysis of the students to find out if there is any connection between the groups they identify with and the module they choose.
3. Examine the impact of these DEI-themed modules in an upper division algorithms course taken by all students in the computer engineering track in our department.

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