

Increasing Student Understanding of Diversity/Inclusion Issues in a First-Year Engineering Classroom

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Introduction

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] [2]. These shifts in engineering education are also beginning to motivate novel forms of pedagogy that embrace social justice issues and highlight engineering's role in creating a more diverse and inclusive society (see e.g. [3]). In this work-in-progress, we describe a novel approach to an introductory electrical engineering course at the University of Texas at Austin tailored to highlight diversity and inclusion issues and report initial results from longitudinal data on the effects of our approach.

Course Structure and Dynamics

In order to promote a more cooperative approach to learning, students were assigned groups (of up to 5 students each) in the very first week of the semester. Group assignments were based on student responses to a separate *Getting to know you* survey conducted in the first class meeting. Data gathered from the survey included students' race/ethnicity, gender, and relevant high school and educational background. Care was taken to ensure that there were no underrepresented populations in the minority in any group. The purpose of the group work was 1) to encourage student interaction, and foster a more active classroom culture, 2) to work on problem solving in groups, thus promoting teamwork, and 3) to provide students a space where they could develop their communication (both speaking and listening) skills. A variety of group activities were used to suit the content being covered. The majority of the activities required each student to participate to foster an inclusive group dynamic.

Programming Assignments

The course content of this freshman level course covered a wide spread of topics such as basic computing concepts, logic circuits, computer microarchitecture, and assembly programming. A fourth of the students' grade was based on programming assignments. While the objective of each of these five 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.

Methods

We designed a longitudinal panel study to investigate the effects of our novel diversity/inclusion-based pedagogical approach on student understanding and value of diversity and inclusion issues. An online survey was administered to the students enrolled in the course ($n = 88$) before the first day of class and after the last day of class. When the survey deadlines were reached, partial survey responses were recorded, and all responses that did not answer any item

were dropped. A total of 81 students responded to the survey at the beginning of the semester, and 49 students responded to the survey at the end of the semester. The data was cleaned and analyzed using R version 3.5.2 in RStudio.

Measures

For this work-in-progress, we focus specifically on one inventory of items seeking to measure whether students' perceived understandings of diversity and inclusion issues in engineering changed over the course of the semester (Appendix A). The inventory used a 5-point Likert scale where 1 = "strongly disagree" and 5 = "strongly agree". Respondents were asked to rank their agreement on statements related to diversity and inclusion in the course. Between the pre-survey and the post-survey, the wording was slightly altered to account for the time point in the semester. Only complete responses (responses that completed the entire inventory at both timepoints) were included in the analysis ($n = 36$). Student pre- and post-responses were then paired using a student identifier. When a student identifier had more than two responses associated with it (i.e. the student completed the survey multiple times), the responses submitted later were dropped.

Results

A two-way repeated-measures ANOVA using the afex package in R was conducted to explore whether there were any significant differences between items in the perceived understandings of diversity and inclusion inventory and timepoints in the semester. A Mauchly test for sphericity found that homogeneity of variances could be assumed for the item variable ($W = 0.68, p = 0.17$), whereas it could not be assumed for the interaction between item and time ($W = 0.56, p = 0.02$). Therefore, a Greenhouse-Geisser correction was employed for the item:time interaction. There was a statistically significant effect of item on perceived understandings of diversity and inclusion ($F(4, 140) = 8.71, p \ll 0.001$), as well as statistically significant interactions between item and time point in the semester ($F(4, 140) = 14.52, p \ll 0.001$).

Post-hoc pairwise comparisons with Tukey correction were computed using the emmeans package in R. Item 3, which measured students' perceived understanding of university and department resources, showed a statistically significant difference across time ($p < 0.001$), whereas item 5, measuring whether students understood the importance of diversity and inclusion, showed a statistically significant decrease across time ($p = 0.01$). Furthermore, comparing the means of the items at each timepoint, at the beginning of the semester, there were no statistically significant differences between the items except for item 5 ($p = 0.003$). At the end of the semester, item 3 showed a statistically significant difference from the rest of the items ($p < 0.001$). Item 4 showed statistically significant differences between items 1 and 2 but not item 5 ($p = 0.01$), and there were no statistically significant differences between items 1, 2, and 5 ($p > 0.10$).

Discussion

Our results show that implementing diversity and inclusion-oriented curricula is one potential approach to exposing the importance of diversity and inclusion in engineering to first-year students, but care must be taken to design and execute assignments suited for the

course content. After having students complete programming assignments that included working with real-world data relating to on-campus resources, students perceived that they better understood the resources that the university, college, and department afforded them as a student. However, with respect to gender and race/ethnicity issues in engineering, where there was a less direct focus, students perceived to have either the same or less understanding of how those issues fit into the fabric of engineering at the end of the semester. This indicates that it is likely that the perceptions of understanding of these issues in engineering for first-year engineering students may decrease without substantive focus on diversity and inclusion by faculty and departments.

Connecting to extant research literature on diversity and inclusion in engineering, work by [4] argues that the decline in perceived understanding may be attributed to a culture of disengagement, in which first-year students are socialized to value technical content in engineering over non-technical content. As a result, engineering students, over time, show less concern for public welfare and diversity and inclusion issues as they progress in their engineering degree programs. As shown here, the processes of socialization can be seen even in the span of a semester. Faculty and academic stakeholders must therefore consider ways to expose first-year students to diversity and inclusion issues so that they see it as relevant to engineering and their experiences as engineers, such as incorporating it into curricula.

Future Work

In the future, we intend to examine interest in diversity and inclusion issues based on race and gender identity as well as the relationships between diversity/inclusion interest, sense of belonging, and engineering identity using our dataset. We will also continue our longitudinal data collection to see if the trends reported here change over time as these students progress in their engineering academic careers.

References

- [1] National Academy of Sciences. (2011). *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*: The National Academies Press.
- [2] A. K. Davis, "Toward Exclusion through Inclusion: Engendering Reputation with Gender-Inclusive Facilities at Colleges and Universities in the United States, 2001-2013," *Gender & Society*, vol. 32, no. 3, pp. 321–347, Apr. 2018.
- [3] Riley, D. (2008). Engineering and social justice. *Synthesis Lectures on Engineers, Technology, and Society*, 3(1), 1-152.
- [4] E. A. Cech, "Culture of Disengagement in Engineering Education?," *Science, Technology, & Human Values*, vol. 39, no. 1, pp. 42–72, Sep. 2013, doi: 10.1177/0162243913504305.

Appendix A: Perceived Understanding of Diversity/Inclusion Inventory

To what extent do you agree/disagree with the following statements before taking EE 306?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Before taking EE 306, I have a good understanding of gender issues in engineering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before taking EE 306, I have a good understanding of race/ethnicity issues in engineering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before taking EE 306, I have a good understanding of the resources UT, Cockrell, and ECE provide me as an engineering student.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before taking EE 306, I have a good understanding of the connection between engineering and social issues.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before taking EE 306, I have a good understanding of the importance of diversity/inclusion in engineering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

To what extent do you agree/disagree with the following statements after taking EE 306?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
After taking EE 306, I have a good understanding of gender issues in engineering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After taking EE 306, I have a good understanding of racial issues in engineering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After taking EE 306, I have a good understanding of the resources UT, Cockrell, and ECE provide me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After taking EE 306, I have a good understanding of the connection between engineering and social issues.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After taking EE 306, I have a good understanding of the importance of diversity/inclusion in engineering design.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>