Impacts of Engineering Justice Curriculum: A Survey of Student Attitudes

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Abstract

As part of a larger project examining the role of humanitarian service learning in engineering (NSF project number EEC-1540301), we conducted an investigation of first-year engineering students' perceptions of humanitarian service learning projects, social responsibility in their discipline, and ethics in STEM. Students (n=231) taking a required freshmen level engineering course were surveyed with a pre- and post-instrument, and provided with these working definitions:

- Community Service is voluntary work intended to help people in a particular community.
- Social Responsibility is an obligation that an individual (or company) has to act with concern and sensitivity, aware of the impacts of their own action on others, particularly the disadvantaged.
- Social Justice relates to the distribution of the advantages and disadvantages in society, including the way in which they are allocated.
- Pro bono- work done without compensation (pay) for the public good.

This course specifically addresses the issues described above with the goal of providing early exposure to topics that will be reinforced in non-major coursework, such as general education elective courses. Results showed that there was little change in student perceptions before and after completion of the course in terms of their perceptions of ethics, social responsibility, and social justice. In the areas in which there were statistically significant changes, students were, on average, slightly less sure the engineering profession can help people or solve social issues and slightly less interested in a job that involves helping people. On the other hand, students were slightly more aware, after the course, of the need to include social aspects in engineering practice and rated technical and professional skills as slightly less important after the class. It was also found that some groups in the class (women, minority students, first-generation students, and student less focused on salary in thinking about their future jobs) entered the class with different attitudes and changed in different ways by the end of the course. Overall, the results of this survey support other findings in engineering ethics which suggests that one course is insufficient to make significant impacts on the ways engineering students think about the societal implications of their work. However, these declines in student confidence, while small, are important to take seriously and this paper will draw out potential implications of this finding. Finally, we will discuss the

implications of the differences within the class in terms of effective teaching of these topics and retention of underrepresented students.

Introduction

In 2002, Herkert [1] noted that there were no "established instructional methods for teaching ethics, nor is there any relevant inclusion of ethics in the undergraduate STEM curricula." And, Riley et al. [2, p. 107] reported that "engineering curricula are increasingly filled with required courses from within the engineering discipline, often leaving students with little room to take elective courses such as engineering ethics." And more recently, Howland et al. [3] asserted "there is a lack of research on foundational understandings of social and ethical responsibility among engineering students, including how their perceptions change over time and following participation in specific types of learning experiences." Despite these challenges, engineering ethics has been maturing and scholarly and professional interest in ethics and engineering, social justice and responsibility, and professionalism has been growing significantly over the years, with more universities using an array of techniques to bring these non-technical content areas into their programs. These techniques include incorporating stand-alone courses, content infused across the program curricula, "micro-insertions" [2], service learning, and project-based assignments, among others. Still, most challenging to engineering education (and faced also by other technical disciplines, for instance computer science), are the following considerations: What are the best pedagogical approaches to bring ethics and social responsibility content into the engineering curriculum? How do we define and measure effectiveness? And, who should be teaching these components–engineering faculty or humanities/philosophy faculty? While we have professional guidelines and codes of conduct through accrediting bodies such as ABET, professional societies and associations such as NAE, ACM, and IEEE, and an emerging literature base, best practices remain elusive. Our results fit into the larger body of engineering ethics education literature, where mixed results of efficacy of ethics infusion are often reported.

Our study is concerned with the model of the stand-alone course in an engineering curriculum. Numerous studies across STEM disciplines, unfortunately, show disappointing results. For example, in a similar pre- and post-test design, Martinez et al. [4] found no significant differences in students' attitudes about environmental ethics after an environmental science course; Dexter et al. [5] found no significant difference after a computer/information technology ethics course. And, in 2015, using the Engineering Professional Responsibility Assessment tool in a survey conducted at seventeen US universities, Canney et al. [6] found that 44 percent of students (n=2200) reported no specific courses in their undergraduate engineering programs influenced their ways of thinking about social justice and engineering. Moreover, students reported design work, projects, and service learning were effective, while pedagogical techniques such as case studies were not cited at all as effective. In another study, Bielefeldt and Canney [7] reported data from five institutions showing no significant change occurred in students' social responsibility attitudes.

As noted earlier, we may not be measuring these concepts correctly–we might not know what to use nor how to use it. In a meta-analysis using ASEE papers from 2011-2016, Watson and Barrella [8] found limitations in the assessment methods and tools used to measure engineering students' learning and understanding of sustainability as an ethical concept. Problems with unvalidated instruments and non-standardized rubrics leave the field with uncertain data.

Others have used mixed-methods methodologies to help with the assessment and measurement concerns. We also employ those methods, and note the value of qualitative data in assessing the efficacy of ethics and social responsibility interventions. Longitudinal studies are also showing some success, with Fuentes et al. [9], Howland et al. [3], and Bielefeldt and Canney [7] all reporting some positive progress. Given the current interest in the field of engineering ethics education, and the desire to identify best pedagogical practices and accurate assessment, these questions regarding what to teach, how to teach it, and how do we know what is working may find answers going forward.

Curriculum Description

A required first year engineering course at the University of Wisconsin-Stout was developed to address the needs of new engineering students while setting the stage for how they might approach engineering work in later curriculum. Broadly, this course supports the program educational objective of graduating students who are "committed to high ethical standards, global perspectives, and principles of social responsibility and social justice." [10, p. 207] The course aims to supplement the technical content typically found in introductory engineering coursework with professional or life skills such as good communication, time management, and ability to function on a diverse team. Course objectives include several that are specifically directed at developing an understanding of engineering ethics, the professional responsibilities of engineering, and social justice through an engineering lens [11–13]. These selected course objectives include:

1. Demonstrate an understanding of the comprehensive nature of engineering design.
2. Evaluate the ethical, social, economic, and environmental impacts of engineering during the design, production, and end user phase of a product's life from multiple perspectives.
3. Synthesize ethically, socially, and environmentally conscious design judgments and decisions.
4. Evaluate trends and future impacts of environmental and social consciousness and globalization on engineering design and manufacturing from multiple perspectives.
5. Apply the engineering design process and employ it to solve real-world issues.

Methods

All students enrolled in ETECH-100: Impacts of Engineering during the Fall 2016, Spring 2017, and Fall 2017 semesters were sent a pre- and a post-survey and given time in class to complete it [14]. The survey combined two existing surveys: The Sustainability Skills and Dispositions Scale (SSDS) [15] and the Engineering Professional Responsibility Assessment (EPRA) [16]. The SSDS includes 28 items that ask students to rate their level of agreement along a 5-point Likert scale from "strongly agree" to "strongly disagree." The items gauge four areas (see Table 1).

Table 1: SDSS Areas

Confidence	Degree to which students feel that they can solve problems, make a positive impact with their work, and work with people who are different from themselves
Global Awareness	Degree to which students see themselves and their work as connected to people across the world, and how much they feel the need to take a global perspective when solving problems
Social Awareness	Degree to which students see that designs have social implications, students' interest in working towards equity and making positive impacts in their community, and their interest in taking the needs of all stakeholders into account
Environmental Awareness	Degree to which students see the need to consider the environmental impacts of designs and have an interest in working towards sustainability

The EPRA survey asks students to rate how important particular skills are for a professional engineer (fundamental, technical, business, professional, cultural awareness/understanding, ethics, societal context, and volunteerism) on a 7-point scale from "very unimportant" to "very important." It also asks students to signal what aspects of a job are most important to them by distributing 10 points among eight categories: salary, helping people, working on industrial/commercial projects, working on community development projects, living domestically, living internationally in a developed country, living internationally in a developing country, and owning your own business. The next set of 47 questions asked students to show their level of agreement (on a 7-point Likert scale from "strongly disagree" to "strongly agree") with statements that measure three realms and eight dimensions (see Table 2 below for an explanation of each).

Finally, students were asked about their experiences with volunteering and a set of demographic questions (gender, engineering major, year in school, GPA, race or ethnicity, previous engineering work experience, first-generation status, religion, and age). The post-test additionally asked students to reflect on their experiences in the course and if they would be willing to do a follow-up interview.

Table 2: EPRA Realms and Dimensions

Realm	Dimensions	Definition
Personal Social Awareness	Awareness	Awareness that there are needs in the community
	Ability	Feeling that one can help meet these needs
	Connectedness	Feeling that it is one's responsibility to meet these needs

Table 2: EPRA Realms and Dimensions

Realm	Dimensions	Definition
Professional Development	Base Skills	Fundamental math and science, technical, business, professional skills and ethics
	Professional Ability	Feeling that the engineering profession can meet needs and make the world a better place
	Analyze	How important cultural awareness and understanding of social context are in professional engineering and how much these areas should be included in design decisions
Professional Connectedness	Professional Connectedness	How important volunteerism and using engineering to help people and work towards greater justice and equity is in being a professional engineer
	Cost-Benefit	To what degree one would sacrifice salary for helping others and to what degree one thinks community service and volunteerism will benefit them and their career

A total of 445 students were enrolled in the course across seven sections. All but one section had between 58-74 students, with one smaller section that had 43. 413 students took at least one survey (pre or post), but not all students took both. Response rates for each semester pre- and post- can be found in Table 3.

Table 3: Class Sizes and Response Rates

Semester		Class Size	Responses	Response Rate
FA 2016	Pre	115	114	99.13%
	Post	111	95	85.59%
SP 2017	Pre	120	109	90.83%
	Post	117	88	75.21%
FA 2017	Pre	201	192	95.52%
	Post	199	166	83.42%

Removing students who did not take both surveys and who answered the “are you paying attention” question incorrectly, yielded a sample of 231. Results from only those students are reported on here.

The students in the final sample are overwhelmingly male (87%) and white (88.3%), largely not first-generation students (75.7%), and between the ages of 18 and 20 (78.7%). 54% report being affiliated with an organized religion, and around half of those who reported being affiliated with an organized religion reported being either somewhat or very active (57.2%).

Table 4: Key Demographics

Gender	**Percentage**
Male	87.4%
Female	10.4%
Gender non-conforming	0.4%
Other	1.3%
Prefer not to say	0.4%
Race and Ethnicity	
African American	1.7%
Asian	2.6%
Hispanic	1.7%
Native American	1.7%
Non-Hispanic White (includes people who wrote "white" after choosing other)	87.9%
Prefer not to say	3.5%
First-Generation Status	
Parents attended college	75.3%
First-generation	24.2%

In addition, all students who indicated a willingness to be interviewed were contacted, and four interviews were conducted. Interview questions asked them about choosing to major in engineering, their current career plans, their plans to use their engineering skills in volunteering, the main things they took from the class, how (if at all) it changed their thinking, how they think about ethics, and if they thought the skills and information from their general education courses would be useful in their careers.

Survey data was analyzed to see if survey responses in any areas changed significantly between the pre- and post-surveys using paired sample t-tests. Results were also analyzed, using independent sample t-tests, to see if groups of students (based on gender, race/ethnicity, first-generation status, and level of important placed on salary at the beginning of the course) had significant differences in their views at the beginning and end of the course and if they changed in different ways during the course. Because the sample is overwhelmingly white, cisgender male, and predominantly not first-generation, regression techniques were not used to analyze the data. There were simply not enough students in other categories to get meaningful results. Interviews and the open-ended survey question that asked students to reflect on the course were recorded and transcribed. Qualitative coding techniques were used to identify the themes that emerged from the data. In this paper, we focus on the quantitative results, using some qualitative data in our discussion to help make sense of these results.

Results

Summary statistics for the survey dimensions and areas analyzed are presented in Tables 5–8. In this paper we discuss the dimensions in both surveys that are directly related to ethics and social responsibility themes as well as student views about non-technical engineering skills and desired future job characteristics. Average scores across the questions in each survey area were calculated. For the SSDS survey data, the potential score in each dimension ranges from 1 to 5, and for the EPRA data, the scores range from 1 to 7 in each dimension and skill. For desired job characteristics, the range of answers is from 0 to 10.

Table 5: SSDS Dimensions

	Minimum	Maximum	Mean	Std. Deviation
Pre_confidence	2.71	5.00	4.11	0.46
Post_confidence	3.00	5.00	4.13	0.46
Change_confidence	-1.29	1.71	0.02	0.41
Pre_global	2.43	5.00	4.07	0.42
Post_global	2.20	5.00	4.06	0.49
Change_global	-1.14	1.00	-0.01	0.38
Pre_social	2.43	5.00	3.76	0.41
Post_social	1.57	5.00	3.81	0.50
Change_social	-2.14	1.14	0.05	0.42
Pre_environmental	2.17	5.00	4.26	0.50
Post_environmental	2.50	5.00	4.28	0.53
Change_environmental	-1.33	1.33	0.01	0.43

Table 6: EPRA Dimensions

	Minimum	Maximum	Mean	Std. Deviation
Pre_awareness	3.80	7.00	5.76	0.71
Post_awareness	3.40	7.00	5.84	0.79
Change_awareness	-2.00	2.20	0.07	0.72
Pre_ability	3.00	7.00	5.38	0.74
Post_ability	2.25	7.00	5.36	0.85
Change_ability	-2.00	2.25	-0.02	0.71
Pre_connectedness	2.50	7.00	5.11	0.92
Post_connectedness	1.00	7.00	5.08	1.04
Change_connectedness	-4.25	2.25	-0.03	0.79
Pre_prof_ability	4.50	7.00	6.28	0.58
Post_prof_ability	3.00	7.00	6.00	0.85
Change_prof_ability	-4.00	2.00	-0.28	0.85
Pre_analyze	2.60	7.00	5.41	0.67

Table 6: EPRA Dimensions

	Minimum	Maximum	Mean	Std. Deviation
Post_analyze	2.40	7.00	5.59	0.76
Change_analyze	-1.80	2.00	0.19	0.63
Pre_prof_connect	2.84	6.74	4.96	0.69
Post_prof_connect	2.58	7.00	4.95	0.80
Change_prof_connectedness	-1.74	1.68	-0.02	0.54
Pre_cost_benefit	3.25	7.00	5.07	0.83
Post_cost_benefit	2.75	7.00	5.08	0.87
Change_costbenefit	-2.50	2.25	0.01	0.77

Table 7: Importance Placed on Selected Skills

	Minimum	Maximum	Mean	Std. Deviation
Pre Cultural Awareness/Understanding (i.e. of your culture, and those of others)	1.00	7.00	5.58	1.11
Post Cultural Awareness/Understanding	1.00	7.00	5.91	1.12
Change Cultural Awareness/Understanding	-6.00	4.00	0.33	1.15
Pre- Ethics (i.e. ensuring all of your work follows professional codes of conduct)	1.00	7.00	6.25	0.92
Post Ethics (i.e. ensuring all of your work follows professional codes of conduct)	1.00	7.00	6.30	1.03
Change Ethics	-5.00	4.00	0.06	0.97
Pre- Societal Context (i.e. how your work connects to society and vice versa)	1.00	7.00	5.74	0.95
Post Societal Context	1.00	7.00	5.83	1.14
Change Societal Context	-5.00	3.00	0.09	1.10
Pre- Volunteerism (for professional and personal reasons)	2.00	7.00	5.26	1.09
Post Volunteerism	1.00	7.00	5.24	1.28
Change Volunteerism	-6.00	4.00	-0.03	1.24

Table 8: Selected Job Characteristics

	Minimum	Maximum	Mean	Std. Deviation
Pre- Salary	0.00	6.00	2.36	1.09
Post Salary	0.00	5.00	2.30	1.29

Table 8: Selected Job Characteristics

	Minimum	Maximum	Mean	Std. Deviation
Change Salary	-4.00	4.00	-0.05	1.19
Pre- Helping People	0.00	7.00	2.24	1.13
Post Helping People	0.00	5.00	2.06	1.16
Change Helping People	-4.00	4.00	-0.18	1.17
Pre- Working on Community Development Projects	0.00	4.00	1.03	0.87
Post Working on Community Development Projects	0.00	4.00	1.06	0.91
Change Working on Community Development Projects	-3.00	4.00	0.03	1.04

Taking the class as a whole, most changes between the pre- and post-tests were small and most were not statistically significant, with some notable exceptions. Students were less likely to be confident that the engineering profession is able to address problems in the world and placed less value on professional skills and on a job that helps people after the class. They were, on average, more likely to see the value in considering cultural and social factors in engineering (the EPRA "analyze" dimension), and more likely to place a greater value on cultural awareness skills in engineering after taking the class (see Tables 9 and 10). In both tables, stars next to significance numbers indicate the level of significance. One star indicates significance at the .05 level (i.e. we are 95 percent confident the difference is not due to chance); two stars indicates the .01 level, and three stars indicates less than .001.

Table 9: Mean change in all survey dimensions.

	Mean Change	Sig. (2-tailed)
SSDS Confidence	0.02012	0.455
SSDS Global	-0.01383	0.581
SSDS Social	0.04629	0.094
SSDS Environmental	0.01304	0.645
EPRA Awareness	0.07370	0.120
EPRA Ability	-0.01630	0.729
EPRA Connectedness	-0.02790	0.595
EPRA Professional Ability	-0.27790	0.000***
EPRA Analyze	0.18522	0.000***
EPRA Professional Connectedness	-0.01982	0.578
EPRA Cost-benefit	0.00797	0.875
EPRA Salary	-0.05195	0.506
EPRA Helping People	-0.17826	0.022*
EPRA Working on Community Development Projects	0.02632	0.704

Table 10: Mean change in importance placed on engineering skill sets.

	Mean Change	Sig. (2-tailed)
Importance of Fundamental Skills (i.e. Math and Science)	-0.084	0.161
Importance of Technical Skills (i.e. conducting experiments, data analysis, design, engineering tools, & problem solving)	-0.119	0.038*
Importance of Business skills (i.e. business knowledge, management skills, professionalism)	-0.066	0.335
Importance of Professional Skills (i.e. communication, contemporary issues, creativity, leadership, life-long learning, & teamwork)	-0.149	0.034*
Importance of Cultural Awareness/Understanding (i.e. of your culture, and those of others)	0.326	0.000***
Importance of Ethics (i.e. ensuring all of your work follows professional codes of conduct)	0.061	0.342
Importance of Societal Context (i.e. how your work connects to society and vice versa)	0.088	0.229

When we broke the class into groups by gender, race/ethnicity, and first-generation status, some interesting patterns emerged. In terms of gender, we broke the class into those who identified as male and those who identified as female. The only reason for this choice was that there was only one student who identified as gender non-conforming (not enough of a sample to draw any conclusions about), one who checked "prefer not to say," and three who chose other. Those who chose other were asked to define that in a text box, and their answers (a question mark, "dolphin," and "attack helicopter")[1] do not provide meaningful information about their gender identity. Thus, all of these responses were omitted from the analysis. A representation of the means of each group and how those changed from pre- to post-test is included in Figures 1–4 below. Stars indicate which pre- and post-differences between the groups are significant, and a thicker line indicates a statistically significant difference pre- and post-survey within the group. The y-axis in each figure varies and does not show the entire range of possible scores (from 1 to 5 on SSDS dimensions, 1 to 7 on EPRA questions and 0 to 10 on job characteristics). Instead ranges were set to make the charts more readable.

[1] Attack helicopter likely refers to internet discussions mocking gender inclusive language and increasing acceptance of transgender and gender queer individuals. Apparently this has become a popular way to "troll" surveys that include gender inclusive options. Dolphin might have been used in a similar way. There is a running "joke" in South Park about one teacher's frequent changing of gender and sexual identities that "inspires" another character to try to have surgery to become a dolphin. This plot line similarly mocks questioning gender identities as being supposedly as ridiculous as becoming an animal. However, we also found one reference to dolphin as a particular gay male identity (similar to "bear"), so it is unclear what was meant by this answer.

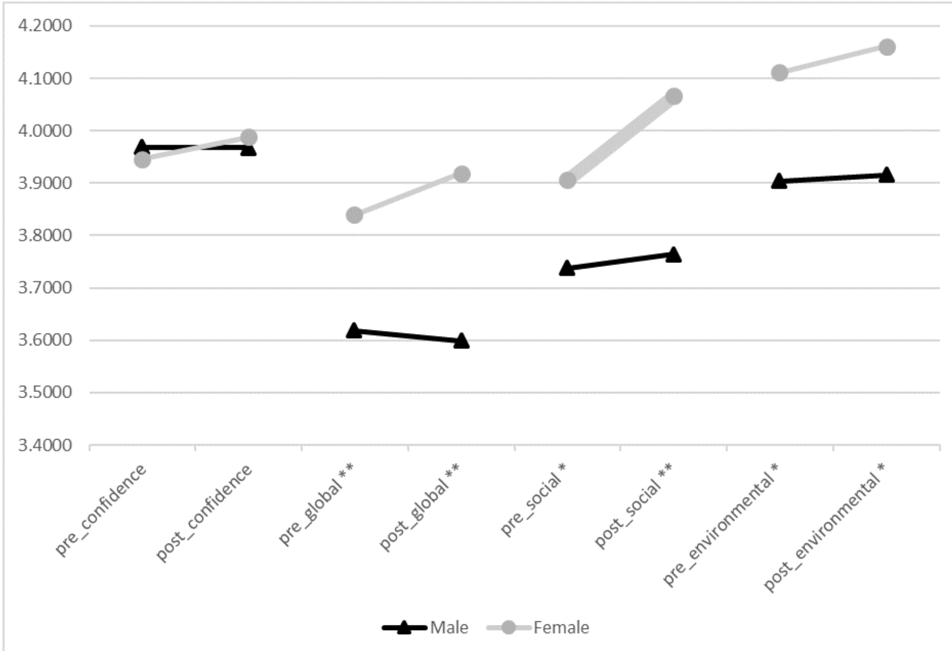

Figure 1: SSDS dimensions changes by gender.

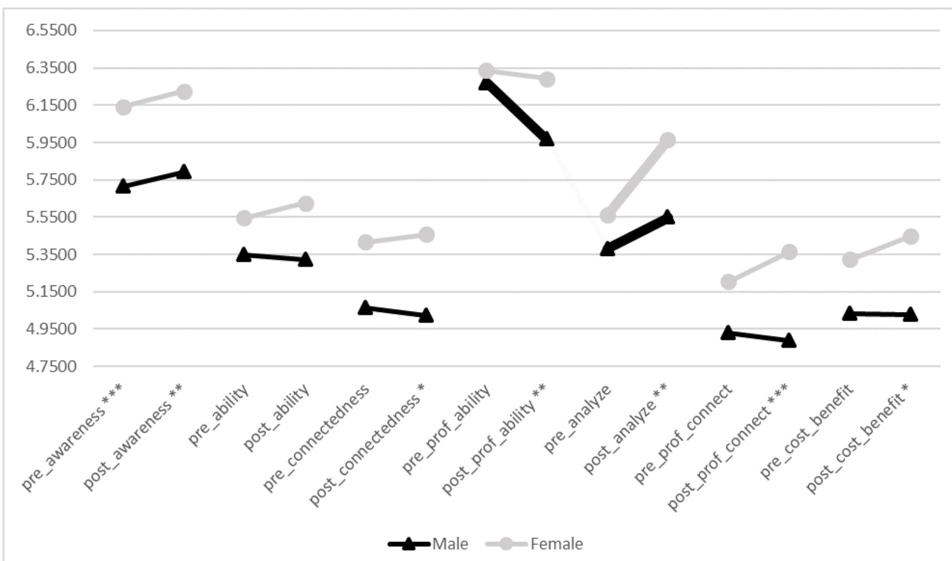

Figure 2: EPRA dimensions changes by gender.

Several of these differences in views between male and female students at the beginning of the class are statistically significant: awareness of global, social, and environmental issues (SSDS), and awareness of community needs (EPRA). In other words, women in the class started out significantly more aware of issues in the world. Several of the differences in the post-test are also statistically significant: awareness of global, social, and environmental issues (SSDS), awareness, connectedness, professional ability, analyze, professional connectedness, and cost-benefit (EPRA). Women, on average, ended the class expressing even more awareness than their male

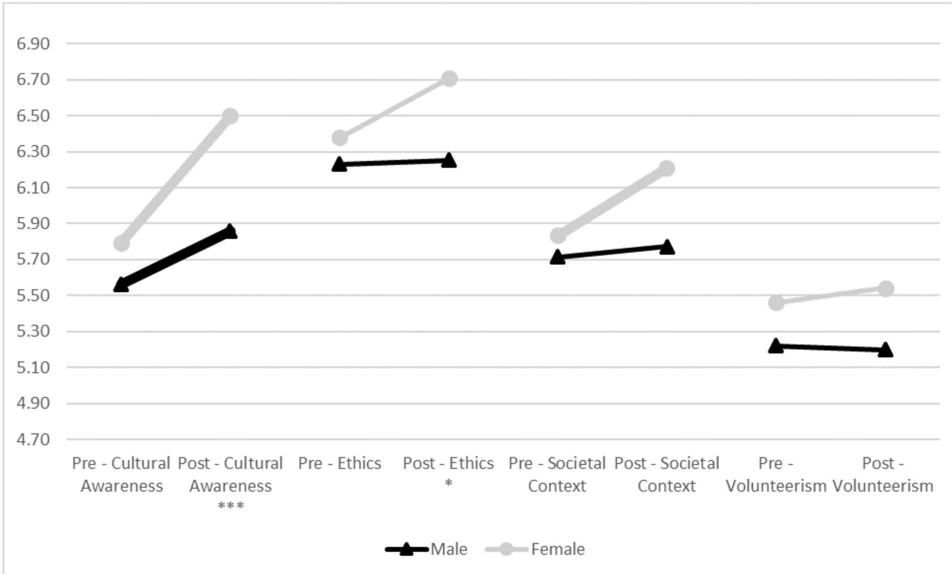

Figure 3: Change in perceived importance of skills by gender.

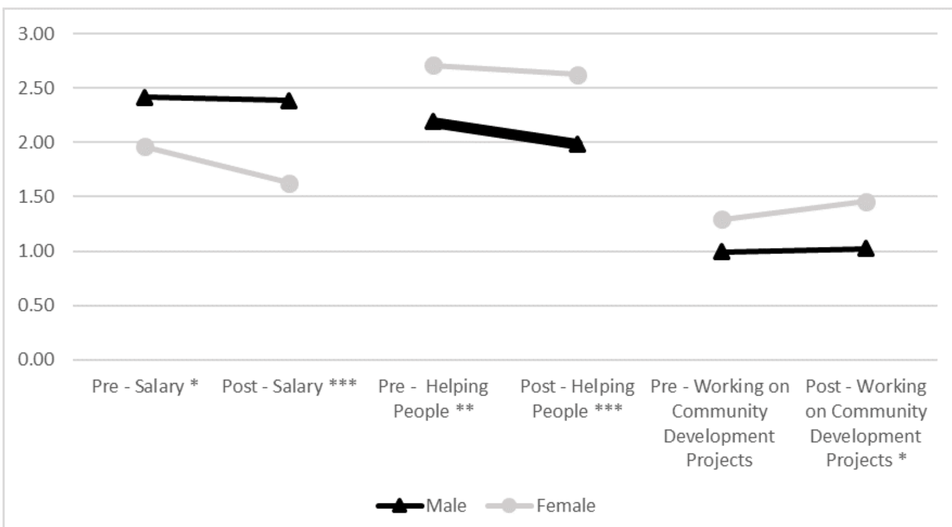

Figure 4: Change in importance placed on job attributes by gender.

counterparts and feeling more that making a difference in the world as an engineer is their responsibility, that they should take cultural and social factors into account in their work as engineers, and that working towards equity and volunteering should be part of the engineering profession. They were also more likely than men to give up salary if they can help others and to see that helping and volunteering can help them as engineers by the end of the course (i.e. the "cost-benefit" dimension). In other words, men and women diverged in their opinions by the end of the class in these areas.

There were no significant differences in where men and women started in terms of the importance they placed on different types of skills, but there were some in the post-test results: cultural awareness and ethics. Men and women diverged in the importance they put on these skills by the end of the course, with women putting more value on these skills than men. There were also statistically significant differences in the job attributes valued by women and men both pre- and post-test. Women started the class placing less emphasis on salary and more on helping people when thinking about desired job characteristics. Women ended the class less interested in salary than men but more interested in helping people and working on community development projects.

In addition, some of the changes pre- to post-survey were statistically significant for women that were not statistically significant for the class as a whole. Women gained awareness of social issues and increased the importance they placed on understanding societal context as a job skill.

We also found interesting differences in the starting and ending points between white and minority students (see Figures 5–8) and between first-generation students and students whose parents attended college (see Figures 9–12).

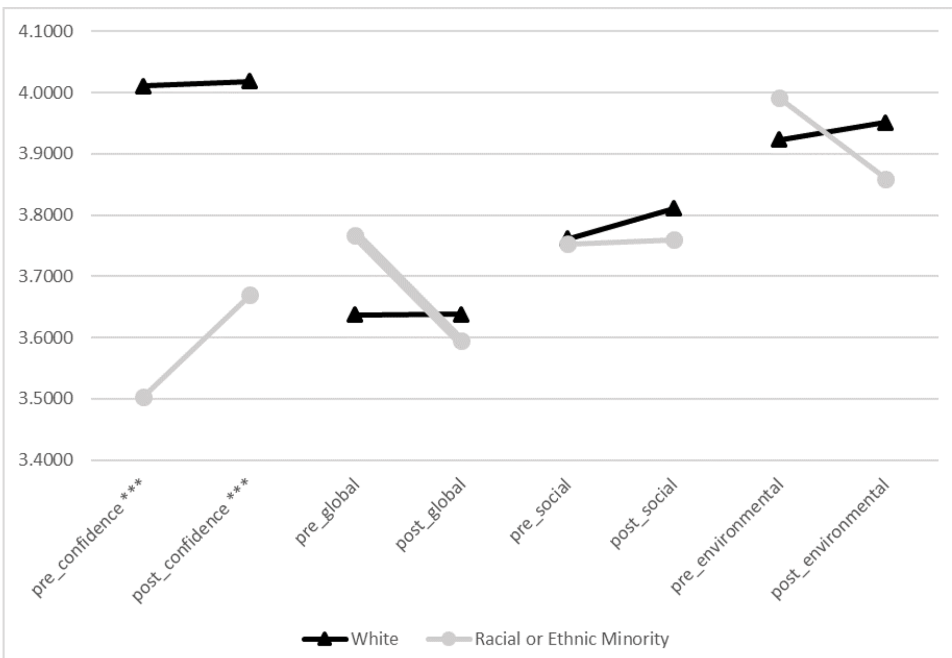

Figure 5: SSDS dimensions changes by race and ethnicity.

Overall, there were fewer differences between these groups. In the pre-survey, there were significant differences between minority and white students in two areas: confidence in their problem-solving ability (SSDS survey), and their feeling that the engineering profession can make the world a better place (EPRA professional ability dimension). Minority students were less confident than white students in both areas. When comparing minority and white students in the post-survey, there were also a few statistically significant differences: confidence (SSDS), awareness, and professional ability (EPRA). Minority students ended the class less confident they can solve problems, less aware of needs in the community, and less sure the engineering professional can make a positive impact.

In addition, minority students showed significant changes in their attitudes that were not significant in the class as a whole: They reported being less aware of global issues as a result of

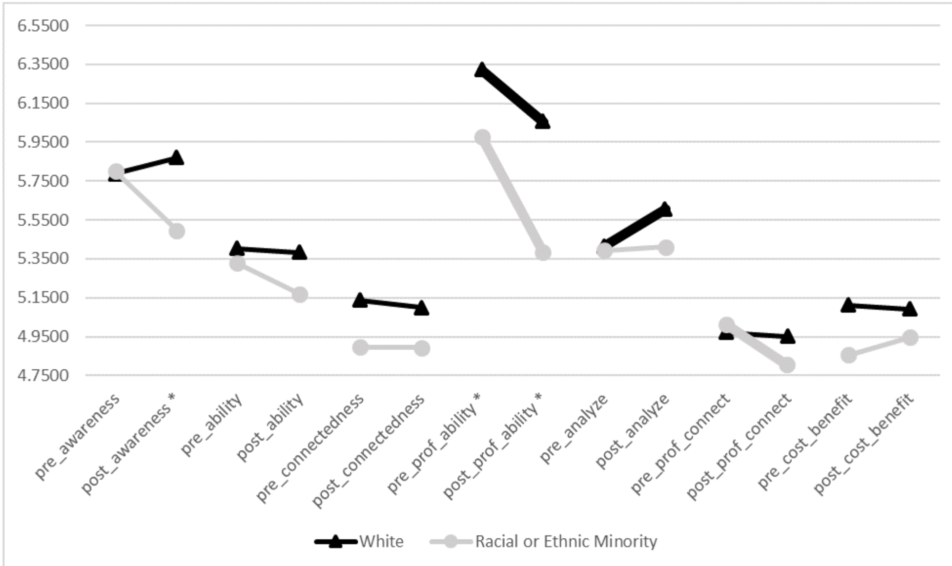

Figure 6: EPRA dimensions changes by race and ethnicity.

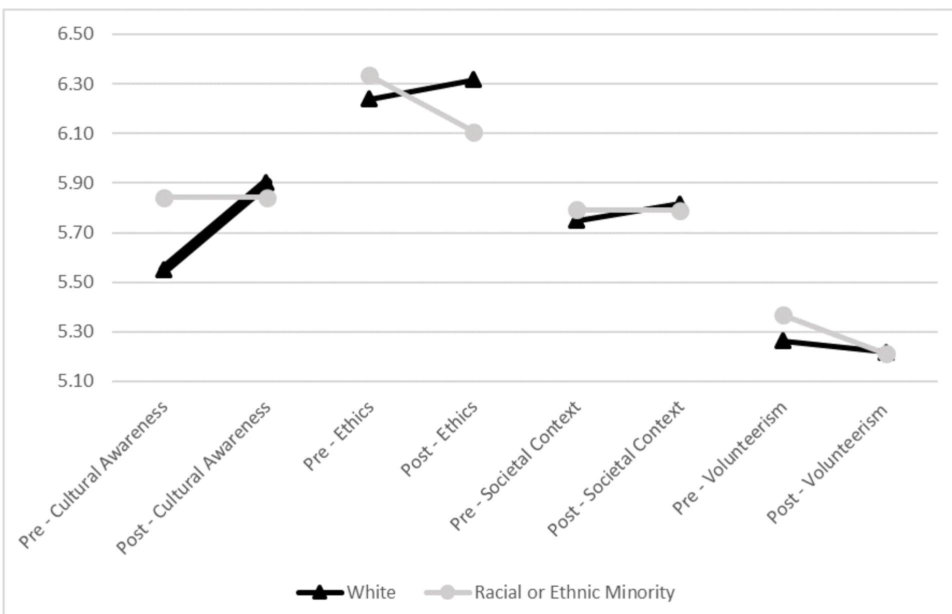

Figure 7: Change in perceived importance of skills by race and ethnicity.

the course, felt less sure that volunteerism and using engineering to help people and work towards greater justice and equity is part of being a professional engineer, and placed less emphasis on salary in their future jobs by the end of the course.

Comparing first-generation student with those whose parents attended college also revealed some interesting patterns. In the pre- results, none of the differences between first-generation and students whose parents attended college found were statistically significant. In the post- results, a few differences between these groups were, however: professional connectedness (EPRA dimensions), cultural awareness, ethics, and societal context (skills). First-generation students

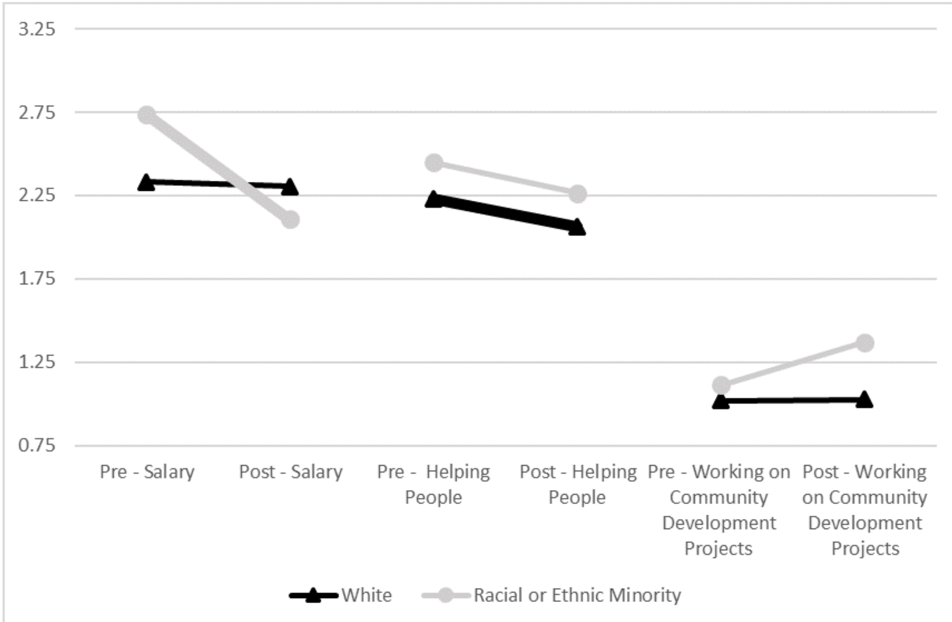

Figure 8: Change in importance placed on job attributes by race and ethnicity.

ended the class more convinced that working towards equity and volunteering should be part of the engineering profession, and that cultural awareness, ethics, and understanding of societal context are important engineering skills.

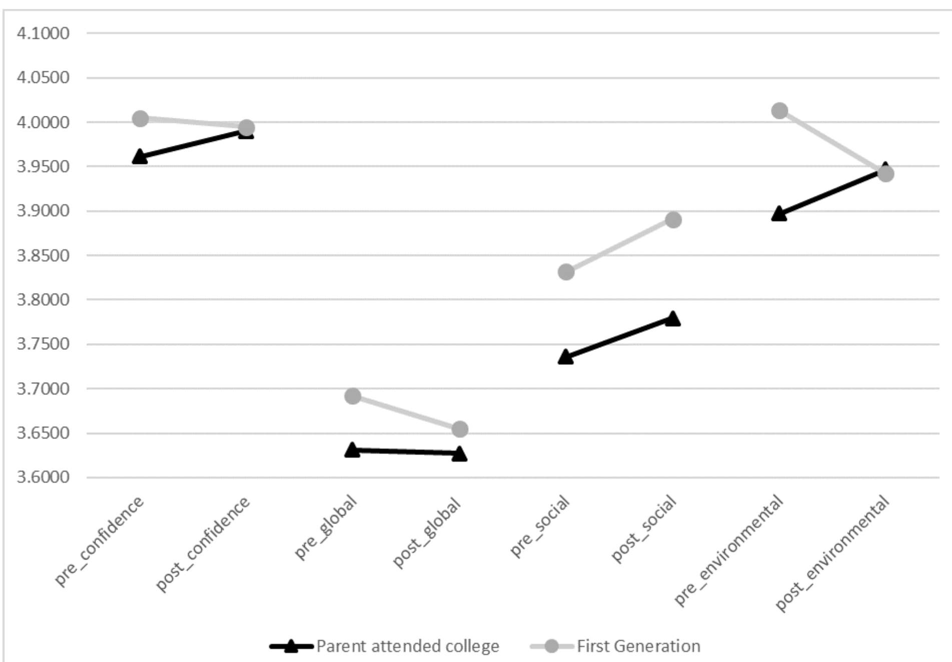

Figure 9: SSDS dimensions changes by first-generation status.

First-generation students also made some statistically significant changes after the course as compared to the class as a whole. First-generation students placed more importance on ethics and

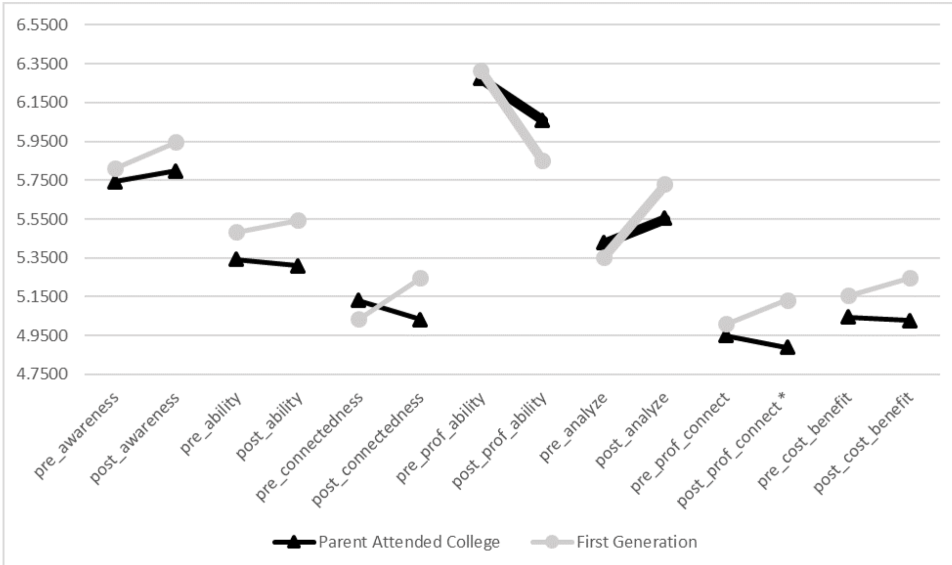

Figure 10: EPRA dimensions changes by first-generation status.

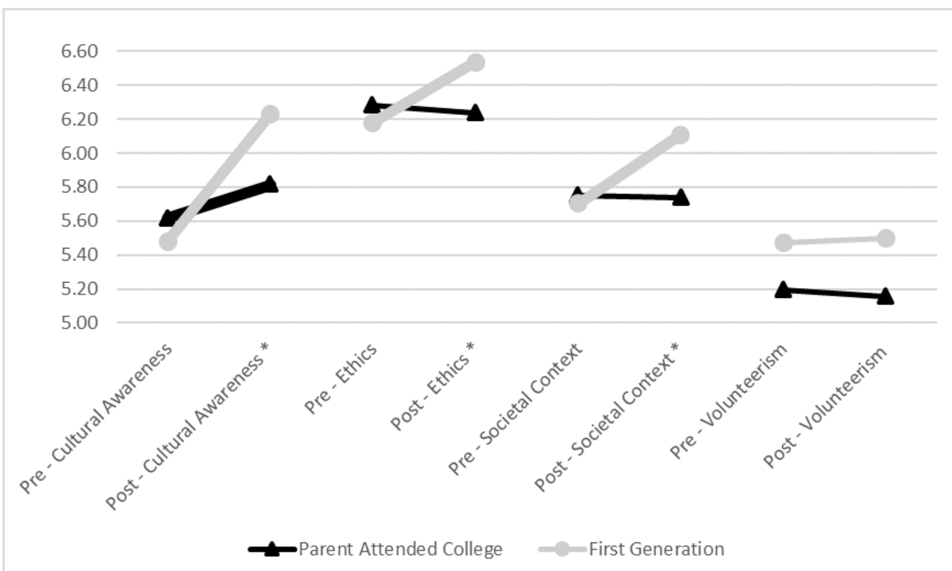

Figure 11: Change in perceived importance of skills by first-generation status.

taking into account societal context when thinking about the importance of various skills in engineering. Students whose parents attended college did make one significant change after the class—they placed less importance on salary in thinking about their future jobs.

Finally, some interesting patterns emerged among students who entered the course placing a high value on salary in their future jobs (i.e. they put three or more points in that area) and those that placed less value (see Figures 13–15).

There are statistically significant differences between these groups in the pre-survey results along many dimensions: confidence and global, social, and environmental awareness (SSDS); ability,

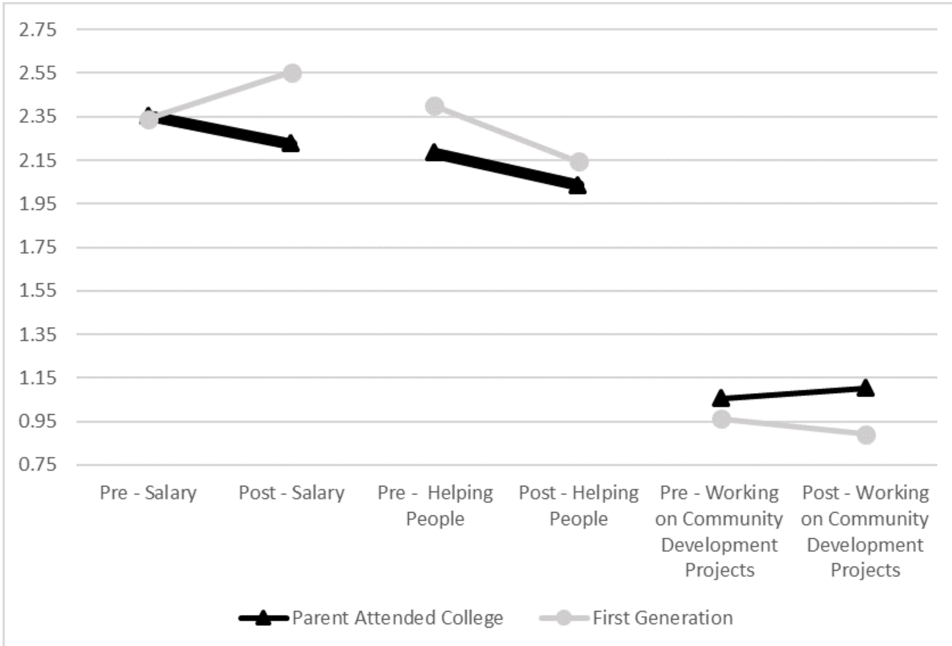

Figure 12: Change in importance placed on job attributes by first-generation status.

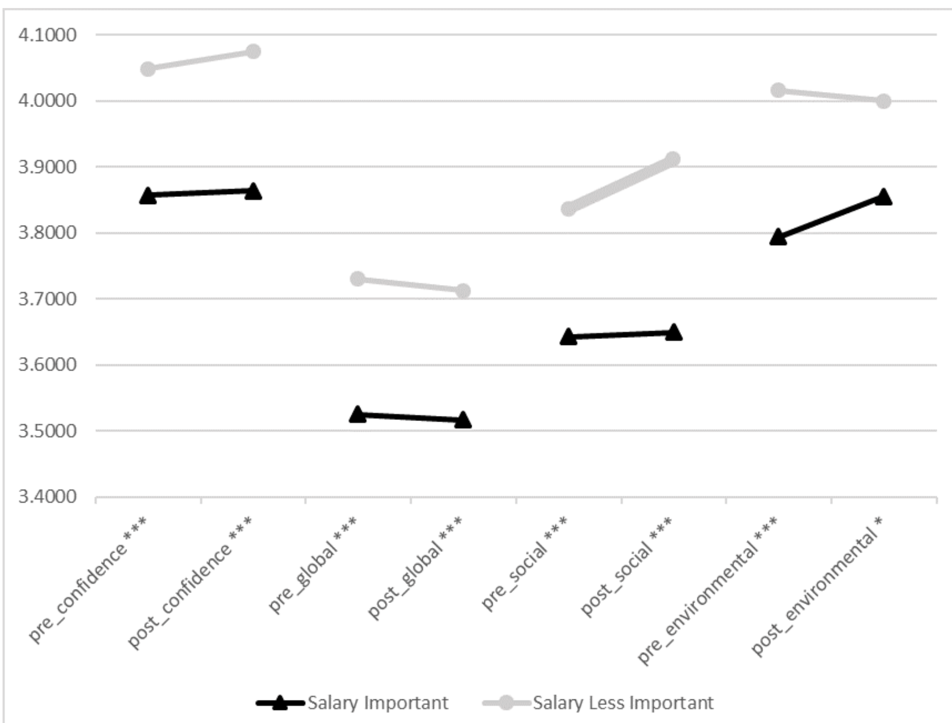

Figure 13: SSDS dimensions changes by importance placed on salary.

connectedness, analyze, professional connectedness, and cost-benefit (EPRA). There are also significant differences in the value these groups placed on various skills (cultural awareness, ethics, societal context, and volunteerism) and job attributes (working on community development

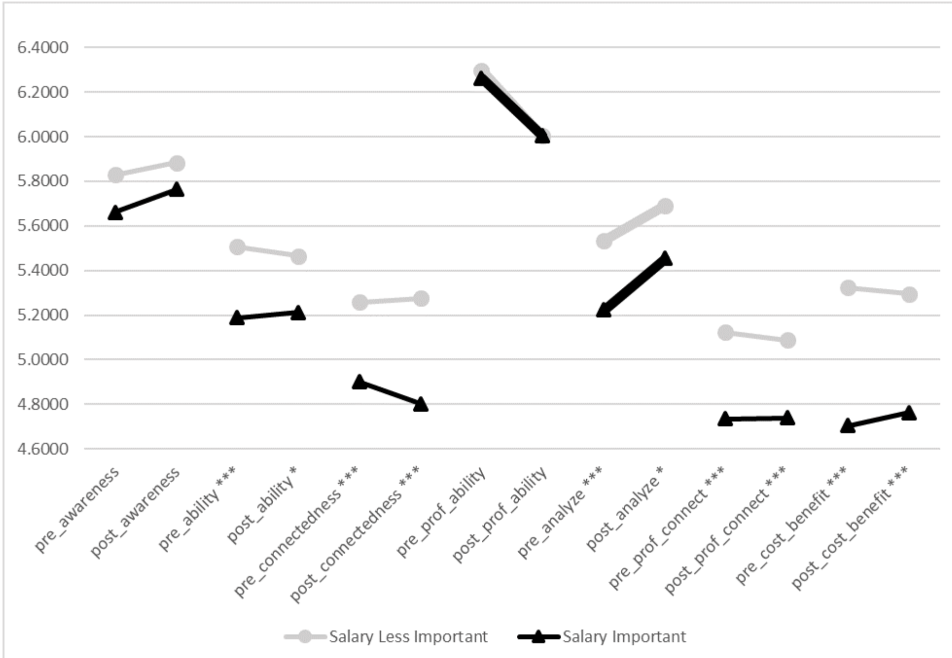

Figure 14: EPRA dimensions changes by importance placed on salary.

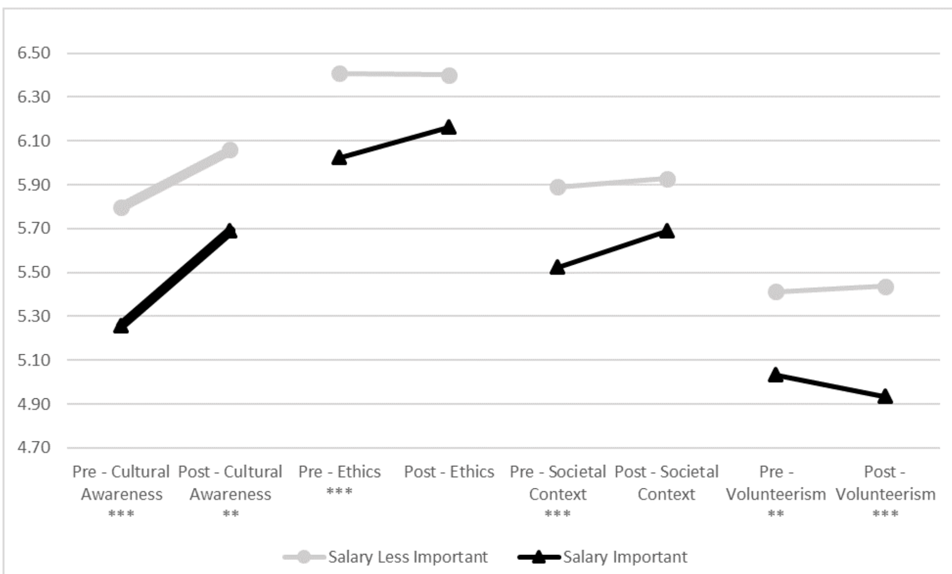

Figure 15: Change in perceived importance of skills by importance placed on salary.

projects). Those who placed less importance on salary at the beginning of the course were more confident in their problem-solving abilities and more aware of global, social, and environmental issues (as measured by the SSDS questions). They also felt more able to address community needs, more that this work is their responsibility, more sure that cultural and social factors should be taken into account in engineering practices, more sure that the engineering profession should work towards equity and helping people, and more likely to be willing to trade salary for the ability to help people and to feel that helping and volunteering will help them as engineers.

In the post-survey there were also statistically significant differences between these groups in several areas: confidence and global, social, and environmental awareness (SSDS); ability, connectedness, analyze, professional connectedness, and cost-benefit (EPRA). They also placed significantly different values on job skills and attributes in the post-survey: cultural awareness, volunteerism, and working on community development projects. Students who placed less importance on salary were more confident of their problem-solving skills and more aware of global, social, and environmental issues (as measured by the SSDS survey). They also felt more able to address community needs, more certain that addressing these needs should be their responsibility, more that volunteering and helping people is important for the engineering profession, and more willing to sacrifice salary and to see community service as benefitting themselves. Finally, they placed more value on cultural awareness, volunteerism, and working on community development projects.

Students who placed less importance on salary when thinking about future job characteristics made one significant change in their attitudes after the class that did not change significantly among the class as a whole: they became more aware of social issues.

Discussion

When looking at these students as a whole, it seems that this semester-long class did relatively little to change their attitudes about the importance of non-technical skills in engineering, their awareness of social issues and community needs, their views about the kinds of skills engineers should value, or the types of jobs they personally will seek. This is not particularly surprising given what we know about learning, how long change takes, and the impact of a single class on students [3, 6, 7, 17]. The class did have a small but significant positive impact on students' feeling that cultural awareness and understanding of social context are important in professional engineering and how much these areas should be included in design decisions. Most interestingly, students on average left the class less confident that the engineering profession can make a positive impact on the world and can work to meet community needs. They also ended the class placing less weight on helping people when thinking about the characteristics they are looking for in their future jobs.

Qualitative data from the survey and follow-up interviews provide some insights into the relative lack of change seen in the survey. A total of 194 comments were gathered in the survey in response to the question "Has this course (ETECH-100) influenced your views of yourself as an engineering professional or your views of the world? If so, please explain." In those comments, 56 students wrote that the class did not change their views, and 16 of those stated that they entered the class with views expressed in the class. As one stated, "It didn't change the overall view of how I felt, it just reassured [me that] what I was feeling was correct." So, for a significant number of students, the class reflected views they already had.

In the interviews, we asked students to expand more on their views of the class and specifically to discuss why students might have left the class less confident about the role of engineering as a helping profession or less interested in personally using engineering to help others. One stated:

> . . . Sometimes learning what we did in the class really makes you open your eyes and

> maybe it is a little bit of an intimidation thing and then that makes it seem like "I don't know if I could do anything with that" and then so therefore, I guess "I can't volunteer" but maybe I thought I could before.

It is thus possible that students gained a more realistic picture of their own abilities and the abilities of the engineering profession, which is not necessarily a negative outcome. Hopefully, classes such as this start a process of change that can be expanded upon across the curriculum, but these results highlight the need to integrate this content in multiple classes.

These general patterns of change over the course of the class did not hold true for some groups, however. Students who were underrepresented in the class, which was overwhelming white, male, and from families with experience in higher education, began and ended the course with significantly different attitudes and demonstrated significant changes that did not show up in the results for the class as a whole. Underrepresented students seem to be more open to integrating non-technical skills and cultural/social awareness into engineering and to seeking careers that emphasize helping and community development over salary.

It is possible that the gender differences we found reflect dominant gender socialization that encourages women to care about connection with others, while first-generation students might be more interested in giving back because they are more attuned to needs in their communities. Several authors have noted that interest in helping and in taking cultural and social factors into account are especially common among women and curriculum that focuses and encourages these orientations might encourage more women to enter engineering [18–20].

Significantly, minority students remained far less confident than white students in their problem-solving abilities and did not make significant gains in their confidence over the course of the class. This persistent gap is concerning and a potential area to address in subsequent semesters. It also highlights a problem that is not uncommon (see, for example Besterfield-Sacre et al. [21], Colbeck et al. [22]). Minority students and white students also diverged in awareness, with minority students reporting lower levels of awareness by the end of the class. One potential interpretation is that these students came into the class being confident in this knowledge because of past experiences and learned more about what they didn't know as a result of the class. This might reflect students becoming more realistic about what they know.

Students who placed more emphasis on salary also had significantly different attitudes and changed in different ways. Classes such as this might make little impact on these students in particular. It is possible that they do not see these issues and skills and important for landing a job with a high salary, although they are still interested in helping people.

Conclusion and Implications

Our findings have some important implications for the teaching of ethics, social justice, sustainability, the impacts of engineering on society, and the value of non-technical skills such as cultural awareness and taking the needs of society and different stakeholders into account. They also have lessons for the effort to train engineers who have a sense of social justice and a desire to engage in humanitarian engineering or engineering to help. A single class might rarely be enough to impart these skills and attitudes, highlighting the need to integrate this content more thoroughly into the curriculum. As should not be surprising, students also bring different orientations to classes that have these goals and are likely to be differently open to these lessons. As others have also noted [23], students' attitudes are important in learning, and meeting students where they are is important. For example, it is perhaps unreasonable to expect students entering engineering for the salary to adopt these orientations easily (if at all). In contrast, making space for this content might help create a more welcoming climate for underrepresented students, helping to recruit and retain them more easily. The engineering profession remains largely made up of individuals who are white, cisgender male, middle-class, able-bodied, and from families with high levels of education, and a more complete integration of social justice and sustainability topics might help create a more diverse profession. As Leydens and Lucena put it, "we are hopeful that 'poking holes' at the boundary between the technical and social will begin to change engineering education in exciting, unexpected ways by making engineering a place all want to be" [10, p. 210]. We agree, and hope that more students are given the opportunity to see, as a gender-non-conforming student in our survey did, "that social justice work (which I am interested in) is not mutually exclusive with engineering. I can do both and therefore can make a difference through my work."

Acknowledgments

This work is supported by the National Science Foundation under Grant No. EEC-1540301. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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