



## Student Perceptions of First-Year Engineering Justice Curriculum

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## Abstract

This complete research paper will describe our qualitative analysis of the impacts of a first-year engineering course which includes curricular elements of social justice, social responsibility, and ethics. We present our interpretation of four interesting results that came out of our mixed-methods study (n=231) in which we surveyed students taking a first-year engineering course on their perceptions of the role of engineering in society and the world. We find that while a single course is unlikely to be sufficient to greatly influence student perceptions, for some sub-groups, the influence was greater than for the study sample as a whole. We specifically highlight four notable findings and discuss their implications.

## Introduction

There has been a growing interest in the inclusion of ethics, social justice, and professional responsibility within the engineering curriculum. Yet, significant challenges face those attempting to introduce such courses, as the breadth of the engineering curricula continues to expand, often through an increase in the number of required courses from within the engineering discipline. This frequently leaves students unable to enroll in elective courses such as engineering ethics or social issues in engineering, if such courses even exist. At the same time, universities are often interested in providing their students with diverse learning opportunities such as service learning, both domestically and internationally. However, students often lack the proper experience or training to deal with complex ethical, cultural, or societal situations that will likely be encountered or the resources to properly participate while carrying out service-learning projects [1].

Numerous studies have been conducted to investigate the impact of various pedagogical and curricular approaches on the transfer of knowledge in ethics and social justice in STEM disciplines, often with disappointing results [2]–[5]. However, it may be that we are not measuring concepts of ethics and social responsibility “correctly:” we might not know what measures to use nor how to use them appropriately. In a meta-analysis using ASEE papers from 2011-2016, Watson and Barrella [6], for example, found limitations in the assessment methods and tools used to measure engineering students' learning and understanding of sustainability as an ethical concept. Others have used mixed-methods methodologies to help with assessment and measurement concerns. Our research team has also employed mixed methods, and we've noted the value of qualitative data in assessing the efficacy of ethics and social responsibility interventions. Longitudinal studies are also showing some success and have reported positive progress [4], [7], [8]. Demonstrating the disappointing results may simply reflect the length of time it takes to realize learning outcomes in this area.

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The scope of this current work is to develop a better understanding of engineering students' perceptions and opinions on topics within the areas of social justice, social responsibility, and ethics within engineering and the impact, if any, of a first-year course in fostering changes in perceptions and opinions among students. The outcomes of this work are limited by the challenge of effecting change through a single course at the undergraduate level and by the limitations in our ability to measure such changes as discussed above. Additionally, as the focus of this paper is on the qualitative assessment of students responses, we are limited in our ability to interpret meaningful information from often brief student responses to our open-ended questions as well as the small number of students who made themselves available for one-on-one interviews. Finally, we are not capturing the overall diversity of engineering students as the students in our final sample are overwhelmingly male (87.4%) and white (88.3%), largely not first-generation students (75.7%), and between the ages of 18 and 20 (78.7%).

## **Research Methods**

We have developed a required first-year engineering course which contains some of the themes commonly found in traditional first-year engineering curriculum, while also significantly infusing engineering ethics, social justice, professional responsibility, and global awareness [9], [10]. This course was intended to lay the groundwork for further study of these topics both within the engineering core curriculum and through the general education curriculum, helping to meet the program education objectives for one of the engineering programs served by the course [11, p. 207]. The study presented here spans three semesters of the course where we surveyed all of the students completing the course (n=231) at both the beginning and conclusion of each semester. The survey combined two existing surveys: The Sustainability Skills and Dispositions Scale (SSDS) [12] and the Engineering Professional Responsibility Assessment (EPRA) [13]. These survey instruments allowed us to collect information on the students' confidence, global, social, and environmental awareness, personal awareness, professional development, and professional connectedness. Students were also asked to complete demographic and open-ended questions related to the student's past experiences. There were two open-ended questions included as part of the survey instrument which were used to gain further insight into students' perceptions.

- 1) Briefly describe any events that have influenced your views of community service and social responsibility.
- 2) Has this course influenced you views of yourself as an engineering professional or your views of the world? If so, please explain.

A small number of students also indicated that they would be willing to participate in one-on-one interviews designed to provide greater depth and insight into the survey results, and only a handful of these responded to requests for interviews. A small number of interviews (n=4, all were male, white, and not first generation) were conducted, and the student responses were recorded and transcribed. For both the open-ended survey questions and interviews, qualitative coding techniques were used to identify the themes that emerged from the data.

This survey work is a part of a larger, mixed-methods project looking at the use of service-learning and humanitarian work in engineering education [14]. This study was determined to be exempt from further review by the University of Wisconsin-Stout Institutional Review Board.

## Results and Discussion

The results presented in this paper build upon the results that were previously reported [15] and will focus on the qualitative analysis of the open-ended survey questions and interview responses. Specifically, there were four interesting results that stood out from our previously reported quantitative analysis that are explained in the four sub-sections below.

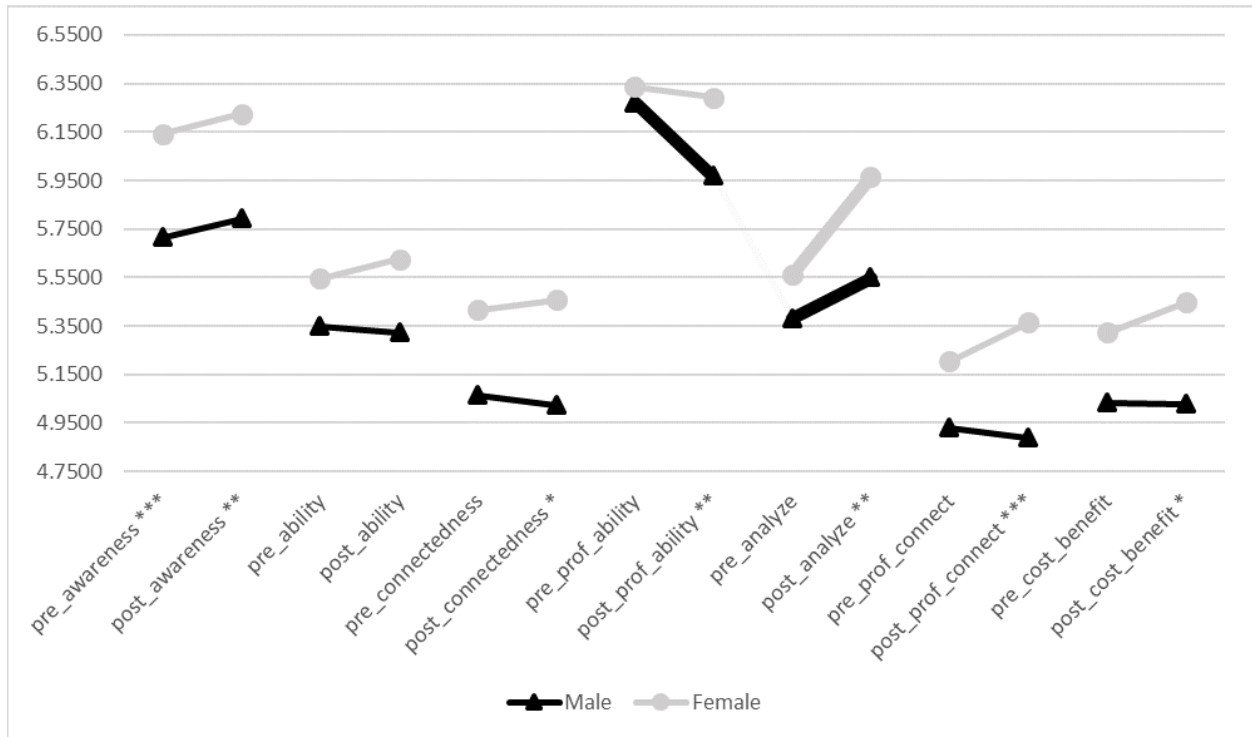
Note that for each of the figures below, stars indicate which pre- and post-differences between the groups are significant. One star indicates significance at the 0.05 level (i.e. we are 95 percent confident the difference is not due to chance); two stars indicates the 0.01 level, and three stars indicates less than 0.001. 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.

*Males generally rated the metrics measured by both the SDSS and EPRA lower than females on both the pre and post surveys.*

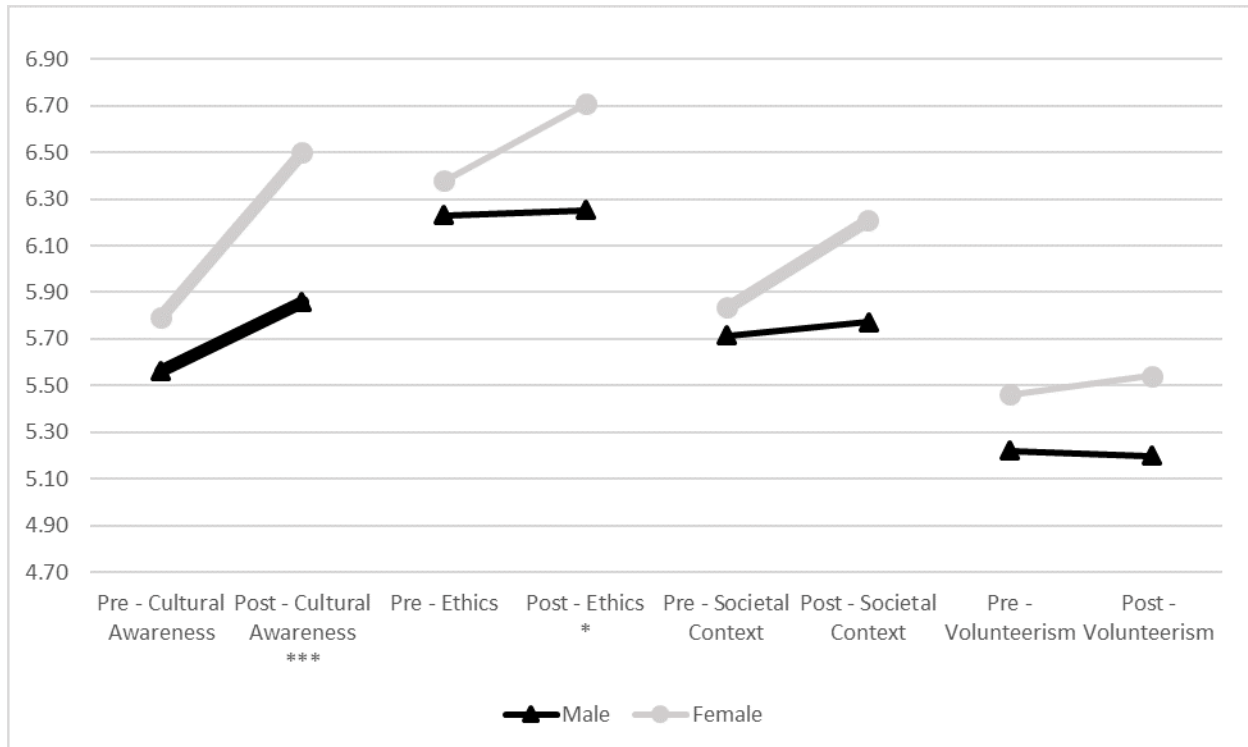
The first result from our analysis that stood out was that when measured on both the SDSS and EPRA metrics, women in the class started out significantly more aware of issues in the world, as shown in Figure 1 and Figure 2. Further, by the conclusion of the course, women had increased their awareness of these issues while their male counterparts remained unchanged or even decreased in awareness. Women were also more likely to say that their view had changed as a result of taking the course. Of the students who said that their views had not changed as a result of taking the course (25.4%), the selection was disproportionately male; 27.8% of male respondents said no while only 6.5% of female respondents stated the same. Women in the class reported that they gained more knowledge about the impacts that can be made by engineers or themselves as well as an understanding of the need to see the “big picture” or “global connections.”

One likely explanation for these results relates to gender socialization. Women are generally more socialized to be focused on others and to value empathy, care, and connection. Other research has found that this can translate to concern for social impacts, environmental impacts, and ethics [16]–[18] as well as to a greater interest in volunteering [19]. In contrast, “competition, rationality, objectivity, and impersonality” are more widely seen as masculine characteristics [20, p. 598]. Previous scholars have also noted that particular skills and fields of study are gendered, with accompanying assumptions about which are thus more appropriate for men and women. “Hard” sciences and technology fields are often read as masculine while humanities, social sciences, and “soft skills” such as communication and ethics are often seen to be more feminine [20]. These patterns might explain why women entered the class more aware of social and environment issues and likely account for the women in our study being more open

to a class about social justice, volunteering, and how engineering can be used to help others than men were (see also [20] for a discussion of men’s resistance to communication skills instruction in engineering). It is important to note, however, that socialization may not directly account for all aspects of how gender differences are expressed through student perceptions. There is some evidence that correlations between empathy or care and social or environmental impacts are gender neutral, but that femininity in women is penalized in science and engineering while being rewarded in men [21], [22]. In our case, however, it seems that women did have substantially different orientations that might explain how they engaged with class material.



**Figure 1. Changes in EPRA dimensions by gender. Figure made available CC-BY [23].**

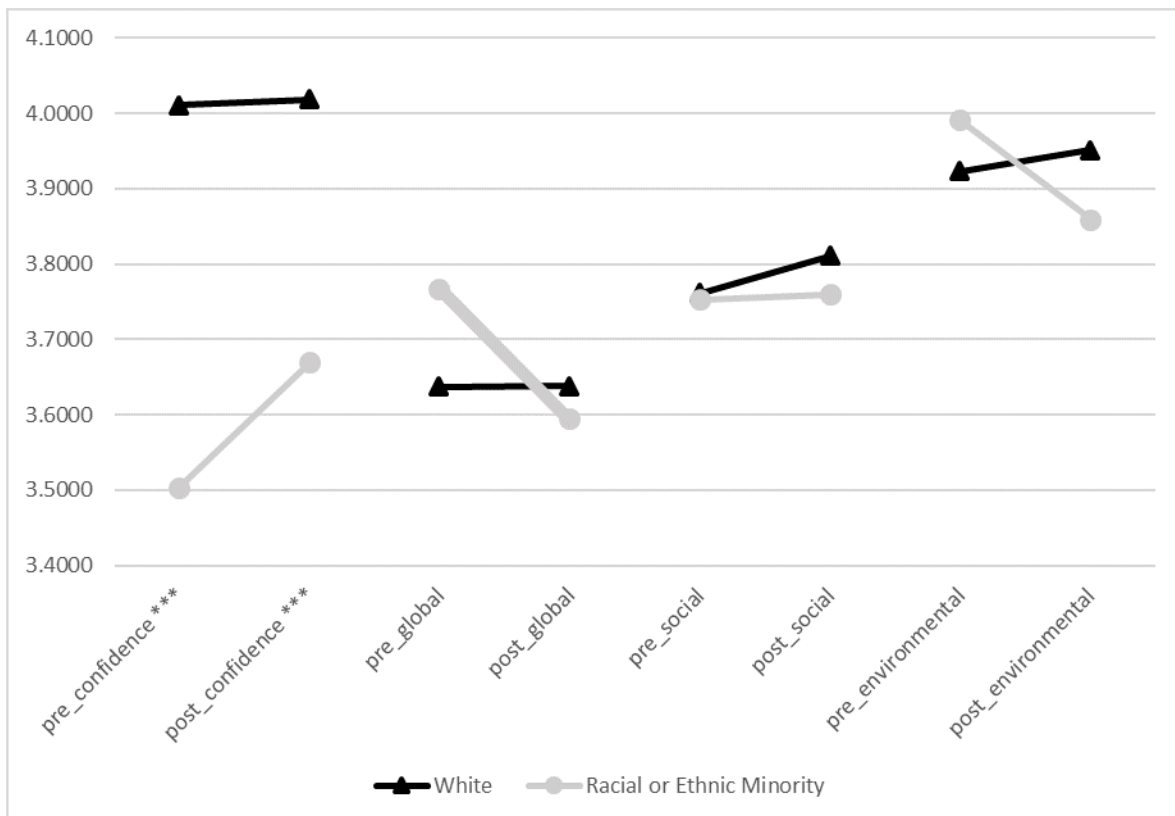


**Figure 2. Changes in perceived importance of skills by gender. Figure made available CC-BY [23].**

*Students who self-identified as belonging to a racial or ethnic minority decreased in their SDSS global awareness and felt less sure that engineering could be used to help people from pre to post while white students did not.*

When looking at the survey results on the basis of racial or ethnic minority status, we found that minority students began and ended the class less confident that they can solve problems than their white peers and less sure the engineering professional can make a positive impact. At the same time, we found that 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 (see Figure 3) as a result of the course and 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. Our ability to interpret this result is limited as many of the racial and ethnic minority students in the sample did not submit responses to the open-ended survey questions and none participated in a one-on-one interview. We offer one observation however: While 27.9% of respondents discussed previous experience with volunteer activities when asking about influences on their views of community service and social responsibility, only one of those respondents identified as a racial or ethnic minority. This same discrepancy was not found on the basis of first-generation status. The apparent lack of experience with volunteering, whether due to lack of opportunity or other reasons, may have influenced the students' ability to connect the material presented in the course with their lived experiences.

It is also possible that racial and ethnic minority students, some of whom were also international students, entered the class confident that they understood how global connections matter, due to their cultural backgrounds and experiences of standing out at a majority white school, but learned more about this topic through the class and realized that they have yet more to learn, decreasing their confidence. For example, one student who identified as multiracial commented: “Probably the biggest lesson I learned from this class is never to assume anything about culture.” Another Native American student commented that she has “A LOT to learn” (capitalization hers). For these students the course highlighted what they do not yet know, and this experience might account for their lack of confidence in their ability to help. More qualitative data from these students is needed to evaluate this hypothesis, however.



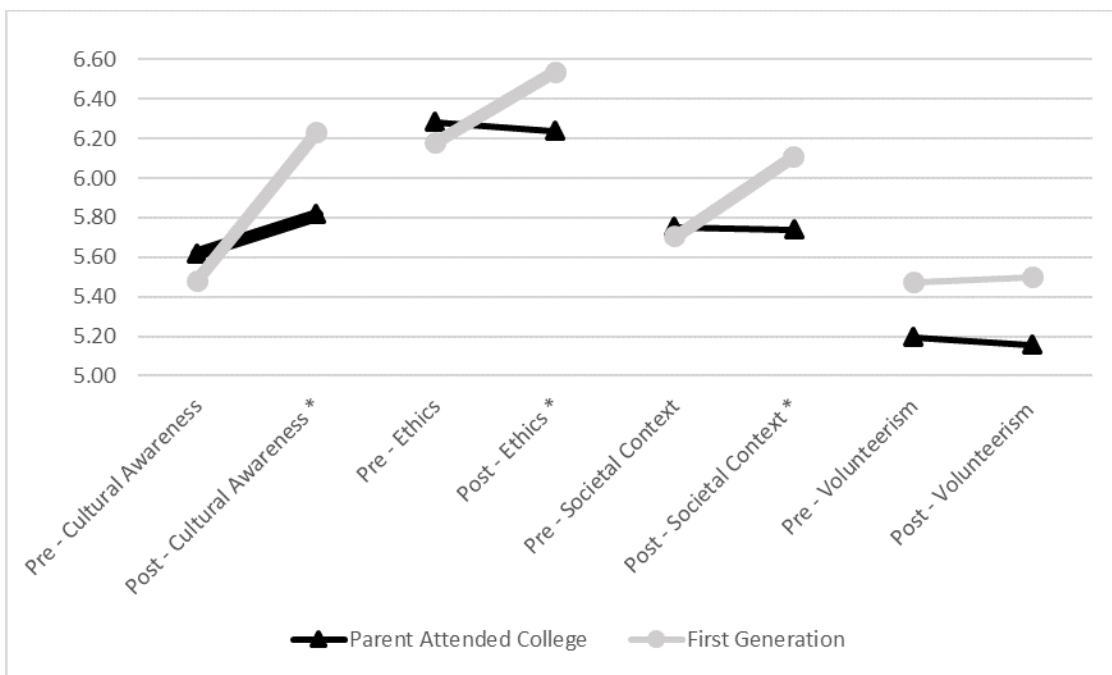
**Figure 3. Changes in SDSS dimensions by race and ethnicity. Figure made available CC-BY [23].**

*First-generation students showed greater gains in cultural awareness, ethics, and societal context than non-first-generation students, who actually showed slight decreases in the latter two metrics from pre to post.*

For the 24.2% of students who identified as first-generation, we found statistically significant gains in the importance that they placed on cultural awareness, ethics, and societal context in engineering work after completion of the course. As shown in Figure 4, on the pre-course survey, the differences between first-generation and non-first-generation students on these metrics were minimal, while after the course, the results from the survey showed statistically significant

differences between the groups. While there was no clear explanation through the responses to the open-ended survey questions, one possibility is that first-generation students are more open to having their perceptions changed through the course curriculum. This result is consistent with other findings in which first-generation college students were noted to have greater educational benefit from exposure to academic coursework in areas such as critical thinking and openness to diversity [24], [25]. Non-first-generation students, in contrast, are more likely to have had experiences which have more strongly cemented their opinions and perceptions of what the engineering field is, perhaps through the influences of their parent’s education or other experiences such as travel. These experiences might have allowed them to form stronger opinions that are less likely to change through a single class.

Many first-generation students in our study specifically discussed their views of the rest of the world as a main change they experienced as a result of the course. For example, one female, white, first generation student commented that the course “has also made me realize that we can learn a lot from other people around the world.” In addition, a male, white, first generation student stated that the course “has taught me to view the world in a new way. Meaning I should do something positive instead of watching it go by.” Another one stated: “This course has widened my perspective on how I view other countries.” It is possible that these comments reflect that, prior to the course, first-generation students in particular had limited experiences with diversity or global issues. This would make sense given that many students at this campus are from the local area, which is rural with an overwhelmingly white population, and that many first generation students are also from families that might not have had the ability to travel or expose students to diversity. These topics, being newer to this group, might have thus had a larger impact.



**Figure 4. Changes in perceived importance of skills by first-generation status. Figure made available CC-BY [23].**



*Students who rated future earning potential as less important to their decision to pursue an engineering career started the course higher and stayed higher on SDSS-measured confidence, global awareness, social awareness, and environmental awareness.*

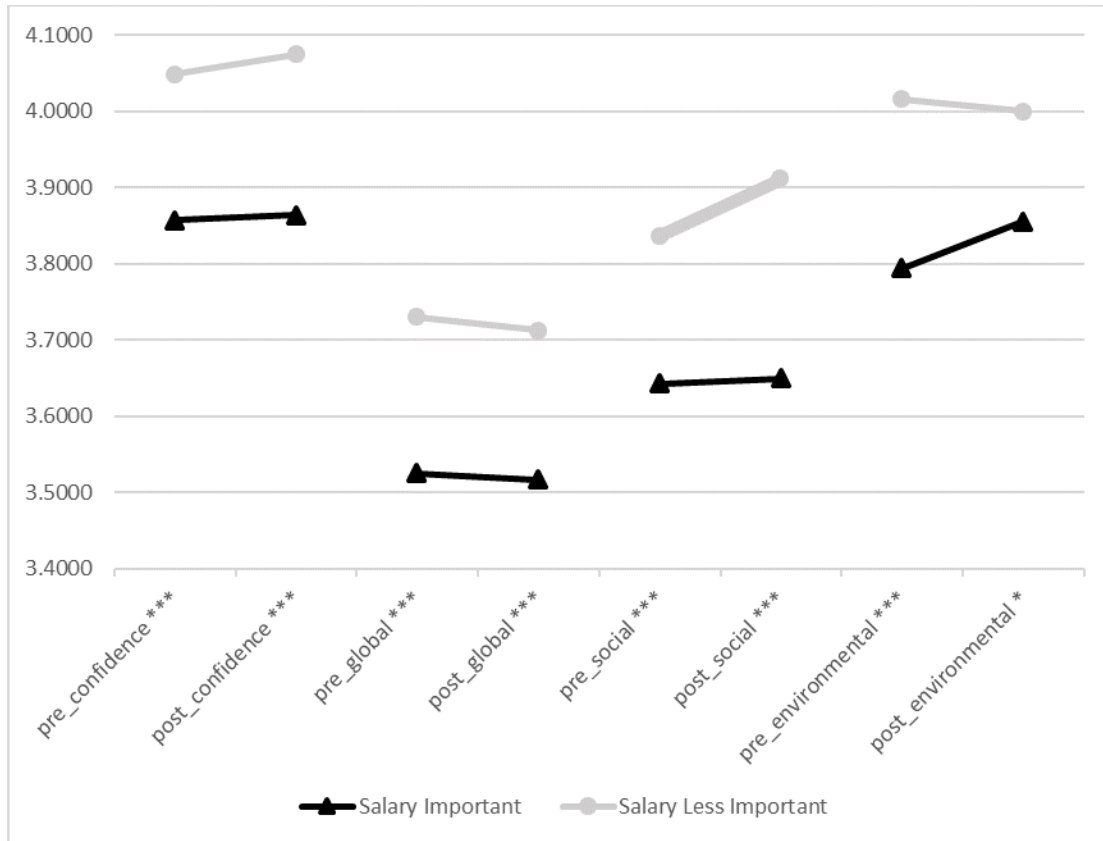
Through the survey, we were able to segregate students who rated their future salary or earning potential as a primary consideration when choosing to pursue a career in engineering; the results are presented in Figure 5. For students who placed higher importance on future salary, they both started the course lower and stayed lower on the measured SDSS dimensions. We generally found that these students failed to make a connection between issues facing society as a whole and their own career trajectory or how those issues may impact them in the future. This is likely because they might think or realize that concern for environmental and social factors and for social justice is not necessary to earn a high salary. It might also be that they ignore these concerns because they have the potential to interfere with earning the highest salaries. One interviewee, who indicated that salary was the most important among all job characteristics (he placed 4 of ten points in the salary bin as opposed to only 1 in working on community development projects and 1 in helping people), when asked why he choose engineering, stated “I just like solving problems, and I like to see and change the world on how people do things.” When asked to clarify what change he was referring to, he responded that he wanted to work in the automotive industry, designing cars and innovating in electric car batteries. He went on to say he hasn’t thought about volunteering, and, when asked if he thought he had any responsibility to give back to the larger community, he mentioned that he could maybe see helping children with robotics in a program like Lego League. When asked what he took away from the class, he talked about enjoying working in teams and that he learned the importance of doing “what’s morally right and do[ing], not what’s best for the company per se, but best for the societies. So, like don’t pollute or break the law to do what’s best for the company.” When asked more about ethics, he talked about contracts and reading the fine print about terms. These responses, provided close to a year after he had taken the course, give some insight into the mindset of a student interested in engineering because of the potential for high salaries. He definitely learned important things from the course, but he seems to have internalized and focused most on the aspects that had the least to do with how engineering can impact society or with the more social justice-focused aspects of the course and more on those that relate to ethics within industry. He also struggled to connect engineering to “giving back” to the community.

In contrast, a student who put only 1 point towards salary and 4 towards helping people, when asked why he decided to pursue engineering, stated that he sees it “as a way to change the world for the better” and talked about improving “the lives of the average person” when asked how it makes positive change. He talked a lot about increasing human happiness through technology and how he has had a long-standing interest in technology and space. The class, however, broadened his view of what engineering can be. He said he saw “how there’s a lot more depth to engineering than I ever thought there was...and how some engineers can go abroad and do little things like digging a well [in a] less modernized country...There’s so many small things that you can do as an engineer as well as these big things too. So that kind of opened my eyes.” In his discussion of the class, we see that his initial belief that the purpose of engineering is to make the world a better place, which outweighs the salary potential of being an engineer, seems to have

made him more open to seeing all the other things that engineering can do, things he wasn't aware of previously.

In addition to the issue of what salary-focused students might be more interested in learning or are more focused on, there is also an issue of personal and political views surrounding social justice topics. One notable student survey response on the issue of community service and social responsibility indicated that people who "expect" help should not receive it and that those who do are "whining" and are "not trying." This response reflects a particularly prominent American point of view, especially among those who are more politically conservative, which holds that people in poverty are there because of their own deficiencies and that too much help will allow them to continue to be lazy and is thus detrimental (see [26] for a discussion of this view and its recent history). It also represents a nihilistic point-of-view in which those in the engineering profession have no influence over nor should have a concern for global perspectives, social implications, or environmental impacts. It may be that a social justice-oriented view of engineering is particularly resisted by many white conservative students and these students are also more likely to value their careers for the potential material gains. It is perhaps not surprising that there exists a negative correlation between students who consider salary of high importance and those who value the global, societal, and environmental aspects of engineering work. Nevertheless, this finding is striking and warrants further study and exploration.

Of course, there are also exceptions to these results. In one particular case, a student who had previous experience working in engineering before returning to school noted that part of the appeal of engineering is that you can form a knowledge base to pursue more money in your career. This student explained that through the curriculum, the course "definitely changed my outlook on what it means to be an engineer in society and how to be respected as one."



**Figure 5. Changes in SDSS dimensions by importance placed on salary. Figure made available CC-BY [23].**

## Conclusions

In this work we have attempted to take a closer look at four notable findings from our study on student perceptions in engineering and the influence of a first-year engineering course in social justice, social responsibility, and ethics. As others have noted, there is difficulty in transferring understanding and awareness as it relates to these topics in STEM disciplines, and further it is unreasonable to expect a single first-year course to significantly influence student perceptions. We would hope to find greater success with an increase in the inclusion of these topics throughout the engineering curriculum and with a scaffolded approach where engineering students can be exposed to social justice, social responsibility, and ethics directly within the context of the engineering problem solving framework. Students bring a diverse set of beliefs, experiences, and desires to the classroom and these profoundly shape how they engage with and internalize class material or how they resist it. We have noted, however, that in some instances, specific sub-groups of students were more receptive than others to the course curriculum and thus their perceptions changed as a result. This was particularly true for students who identified as female or first-generation and those who placed less importance on future earnings as part of their reasoning for pursuing engineering. Conversely, we also found that students who identified as racial or ethnic minorities decreased in their awareness of global issues and less confident that engineering can have an impact on the issues facing society. This might reflect their overall

lower level of confidence in their problem solving-abilities, or, more positively, an openness to learning in the future and a humility about what they do know.

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