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Evaluating the inclusion of environmental justice in the civil engineering curriculum: Does it motivate students to work against inequity and strive for environmental and social justice?

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1 Introduction

Environmental and public health problems affect the populations unequally. Marginalized communities, often based on race, ethnicity, or socioeconomic status, are disproportionately exposed to higher levels of environmental hazards such as pollution, toxic waste, and lack of access to clean resources [1]. These communities frequently bear a heavier burden of negative environmental consequences than more affluent or privileged communities, resulting in significant disparities in health outcomes and quality of life. This inequitable distribution of environmental risks and benefits is not accidental but rather the result of systemic factors, including discriminatory policies, practices, and societal biases [2], [3]. The environmental justice movement emerged in response to this injustice, advocating for the equitable distribution of environmental burdens and benefits and demanding recognition of the interconnectedness between environmental and social justice [4]. Environmental justice is intrinsically linked to social justice because it highlights how environmental inequities are a manifestation of broader social inequalities, rooted in historical and ongoing power imbalances. Addressing environmental injustice, therefore, requires not only environmental solutions but also fundamental shifts in social structures and policies to achieve genuine equity.

Civil engineering, especially environmental engineering, plays a major role in environmental injustice. Engineering structures such as highways, airports and dams have displaced and isolated local communities, especially minority communities in the USA and in the world [5], [6], [7], [8], [9], [10]. Similarly, environmental engineering projects such as landfills and superfund sites have historically been constructed in areas populated by minorities,

increasing their exposure to hazardous pollutants [11], [12]. Indeed, these projects were the main driving force for the environmental justice movement. This injustice stems from poor decision-making from engineers and policy makers who are focused on science and economics without considering the effects on local underrepresented communities. Therefore, it is imperative that engineers receive a comprehensive education in environmental justice principles to effectively contribute to a just society. Understanding the social, economic, and historical contexts that underpin environmental injustice allows engineers to critically assess their projects and their broader societal implications. This knowledge empowers engineers to identify and address potential biases in their work, develop equitable solutions that benefit all communities, and advocate for policies that support environmental justice. By incorporating environmental justice considerations into their professional practices, engineers can directly contribute to reducing environmental inequities, improving public health, and promoting social equity. Engineers trained in environmental justice are essential to designing sustainable and just solutions for the challenges facing our world today.

In this study, the effect of teaching environmental justice to civil engineering majors on their attitudes toward social and environmental justice was studied. Environmental justice was introduced as a module in a junior-level environmental engineering course. There were 12 students in the class. The environmental justice movement and its significance were exhibited to the students. Additionally, cases of environmental injustice and success stories where communities fought against environmental injustice were presented to them. The students then worked on a research project investigating environmental hazards and potential solutions that help all the stakeholders, including underrepresented communities. To test the effect of adding

this module on students' perceptions on social justice, the students were asked to complete the Generalized Professional Responsibility Assessment [13] twice: once before starting the module and once after completing the module. The results of this assessment were used to determine changes in student perceptions.

2 Methodology

2.1 Introduction to Environmental Justice

Environmental justice was introduced as a module in the Sustainability and Environmental Engineering course to educate the students on environmental justice while teaching them about environmental engineering fundamentals. Since environmental justice primarily deals with the disproportionate exposure of environmental hazards to disadvantaged communities, the author deemed fit to introduce the module in this course. The module also aligned with the University's ideals to develop a just society and to promote integrity, social justice, and the growth of people from all communities.[14] Through this module, the author wanted to show how environmental engineering is connected to social and environmental justice. Coursework in the module involved teaching the students about the history of the environmental justice movement and its significance in public health and environmental engineering. Students were presented with various instances where government policies regarding the environment disproportionately affected minority communities. Notable examples included disposing of hazardous waste in native American reservation sites[15] and developing waste management facilities in neighborhoods populated primarily by people of color [16]. In addition, cases were presented where government policies indirectly increased the exposure of minorities to environmental health hazards, including the study that found that people living in redlined areas

were more prone to air pollution [17]. Finally, success stories were shared about individuals who protested for their rights and successfully removed health hazards from their communities.

These case studies were examples for the students to provide them with possible strategies to fight environmental injustice in their communities. The students were assigned a research project (**Figure 1)** where they were tasked to find environmental hazards in their neighborhood. They were asked to use the course curriculum to develop engineering solutions for the issues. Then, the students were asked to find the effects of their solutions on the people in the neighborhood communities. This made them realize that many of their solutions were not beneficial for the local communities and in some cases, even adversely affected them in certain cases. This introspection motivated them to change their solutions to ensure inclusive solutions that address the issues while benefiting local communities. Note that the students were not required to interact with the people in their communities to evaluate the effects.

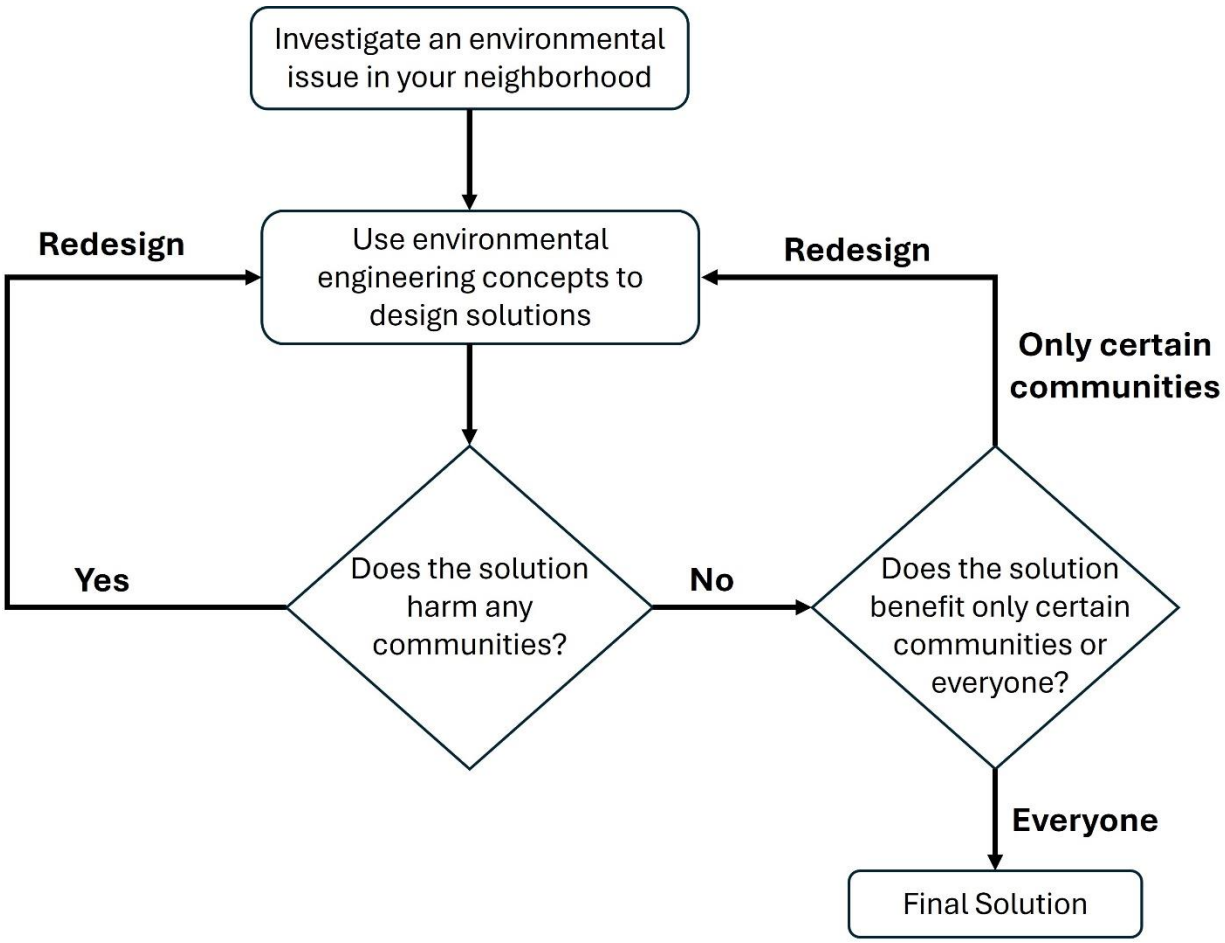

Figure 1: Flowchart summarizing the research project methodology

2.2 Assessment

To assess the effects of the module on the attitudes of the students towards social justice, the Generalized Professional Responsibility Assessment (GPRA) [13] was used. This assessment measures changes in students' attitude towards professional social responsibility. Additionally, certain questions in the assessment test the students' views on environmental social justice and their commitment to helping disadvantaged communities. These questions were thus selected for this project and grouped into three research questions:

1. **Is there a need for environmental social justice?**

- There are people who have needs which are not being met
- There are not people in the community who need help
- Community groups need our help
- I think people who are more fortunate in life should help less fortunate people with their needs and problems
- America does not have communities that need help

2. **Is there a need for social justice in engineering?**
   - The skills in my intended profession are not useful in making the community a better place.
   - People in my intended profession should use their skills to solve social problems.
   - Helping others is a central message in my intended major.
   - People in my intended profession can have a positive impact on society.
   - I feel called to serve others through my intended profession.
   - I view my intended profession and community service work as unconnected.
   - Service should not be an expected part of my intended profession.
   - It is important for people in my intended profession to consider the potential broader impacts of technical solutions to problems.
   - People in my intended profession have contributed greatly to fixing problems in the world
3. **Is it important for me to help people from disadvantaged communities?**

- I cannot have an impact on solving problems that face underserved communities internationally.
- I think I should help people who are less fortunate with their needs and problems.
- My contribution to society will make a real difference.
- I feel an obligation to contribute to society.
- It is my responsibility to take some real measures to help others in need.
- It is important to me to have a sense of contribution and helpfulness through participating in community service.
- I can have an impact on solving problems that face my local community.
- It is not my responsibility to do something about improving society.
- I do not think it is important to use skills gained from my intended profession to serve the greater community.
- I believe that I will be involved in social justice issues for the rest of my life.
- It is important to use my professional abilities to provide a useful service to the community.
- I think it is important to use the skills gained from my intended profession to serve others.
- I will use the skills gained from my intended profession to help others.
- I would not change a design or recommendations because they conflicted with community feedback.
- I can make a difference in my community.

Students were asked to complete the assessment twice. A pre-survey was performed before the module was started and a post-survey was performed at the end of the semester after the students submitted their project reports. The survey asked the students to rate their agreement with the questions on a 7-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree”. The author evaluated the students’ responses to the pre-and-post-survey questions and determined how the module influenced the students’ thoughts on social justice. Note that the students answered all the questions in the GPRA. The author selected the questions relevant to social and environmental justice from the assessment for this study and analyzed the students’ responses to those relevant questions.

3 Results and Discussion

3.1 The module affirmed the need to help communities

The respondents previously had some concept of social justice as only a small fraction of the surveyed students was doubtful of the relevance of social justice in the US (**Figure 2**). Before receiving instruction on environmental justice, only 9% of respondents disagreed with the statements that there are individuals in the U.S. with unmet needs (Survey question 1), that community groups require assistance (Survey question 3), and that those who are more fortunate in life should support those who are less fortunate (Survey question 4). Additionally, only 18% of the respondents didn’t believe that there were people in their community who need help (Survey question 2). Finally, all the respondents disagreed that America doesn’t have communities that need help (Survey question 5).

The module reinforced the students' belief that there are communities in the US that are disadvantaged and there is a need for social justice in the US. After completing the module, the 9% of the respondents who initially disagreed that more fortunate people should help the less fortunate ones softened their stance, and 100% of the respondents agreed that fortunate people should help the less fortunate ones (Survey question 4). Similarly, all the respondents believed that people in their community need help (Survey question 2). This was not limited to the community, as all the respondents disagreed and strongly disagreed that America doesn't have communities that need help (Survey question 5). However, the percentage of respondents who agree that community groups need our help (Survey question 3) and there are people whose needs are not being met (Survey question 1) decreased from 91% to 57% and 91% to 71% respectively.

Through this module, the author sought to show how social inequalities lead to environmental injustice which, in turn, deepens inequalities in society. Several instances were brought forward to the students where socio-economic conditions and government policies led to minority communities being disproportionately exposed to environmental hazards[18], while also not having access to quality healthcare services. This environmental injustice has led to more healthcare issues with people from minority communities [19], [20]. Exposure to these cases reinforced the students' behavior about the inequalities prevalent in American society. In addition, they were able to see that these social inequalities affect the health and life expectancy of the people. This made them realize the importance of the social justice and environmental justice movement and its importance in giving people a safe healthy life irrespective of their backgrounds. They realized that minority and underrepresented communities need help, and it is

the responsibility of the people from fortunate communities to help the less fortunate communities.

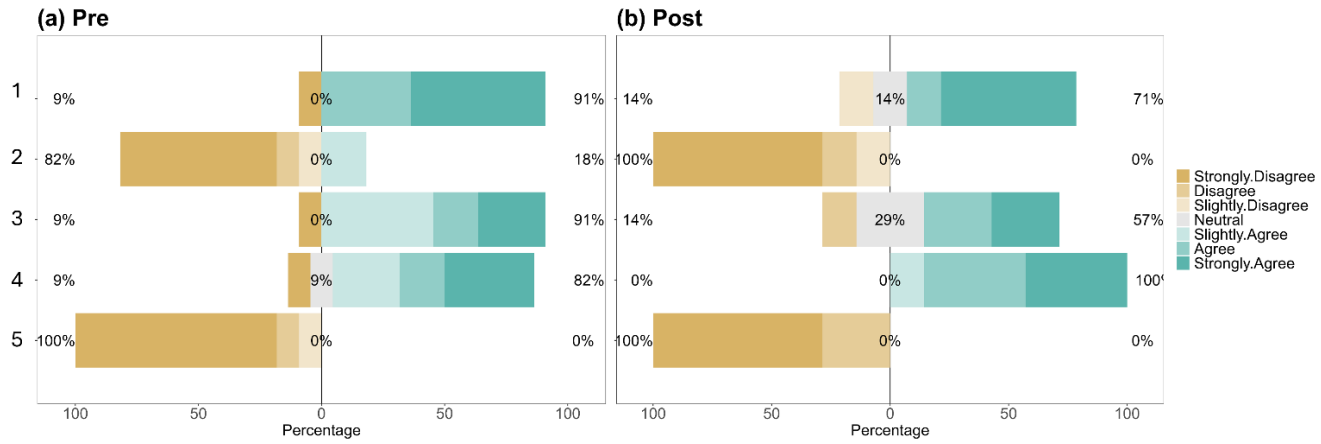

Figure 2: Responses to survey questions on research question 1 (Is there a need for environmental social justice?) before (a) and after (b) completing the module on environmental justice. The survey questions were: 1: There are people who have needs which are not being met, 2: There are not people in the community who need help, 3: Community groups need our help, 4: I think people who are more fortunate in life should help less fortunate people with their needs and problems, 5: America does not have communities that need help

3.2 Students realized the importance of social justice in engineering

The module made the students aware of the importance of engineering, especially environmental engineering, in promoting social justice in the US. After completing the module, all of the respondents agreed that the skills that they learn in their profession are useful in making the community a better place (Survey question 1), compared to 92% of the respondents before working on the module (**Figure 3**). All the respondents also agreed that people in engineering can and have contributed to solving world problems and have a positive impact on society (Survey questions 9 and 4). In addition, a higher percentage (83% to 86%) of the respondents agreed that people in engineering should use their skills to solve social problems

(Survey question 2), and that they feel called to serve others through their profession (67% to 86%, Survey question 5). They also disagreed that engineering and community service are unconnected (58% to 86%) and that service should not be expected to be part of engineering (75% to 86%, Survey questions 6 and 7). However, fewer respondents agreed that helping others is a central message in civil engineering, down from 82% to 57% (Survey question 3). Additionally, fewer respondents agreed that people in engineering should consider the potential broader impacts of the technical solutions to problems (Survey question 8), which is an important aspect of environmental justice.

Civil engineering, particularly environmental engineering, plays a crucial role in addressing environmental and social injustices. Environmentally sound engineering practices can help mitigate pollution, reduce waste, and conserve resources, thereby contributing to environmental justice. To ensure environmentally sound engineering practices, engineers must be trained to consider the views of all stakeholders while planning projects, including the local and underrepresented communities whose feedback is rarely considered [1], [21]. To address this social injustice, students participated in a two-stage research project. In the first stage, they identified and analyzed environmental challenges affecting their local neighborhoods, applying their engineering and technical knowledge to develop practical, cost-effective solutions. At this point, considerations of environmental justice were intentionally omitted. In the second stage, students conducted a more comprehensive analysis, focusing on the communities residing in the targeted areas, with particular attention to underrepresented populations. They were instructed to evaluate how their proposed solutions might affect these communities. This process encouraged critical reflection on the broader social implications of their work and highlighted the potential

for engineering solutions to either mitigate or exacerbate existing inequalities. During project presentations, many students reported a heightened awareness of their capacity to contribute positively to society through their chosen profession and understood their responsibility to work for underrepresented communities. Although fewer students agreed that it is important to consider the potential broader impacts of technical solutions, respondents did not disagree with the statement, they adopted a more neutral stance on it. Indeed, after completing the module, the number of respondents who disagreed with the statement dropped from 8% to 0.

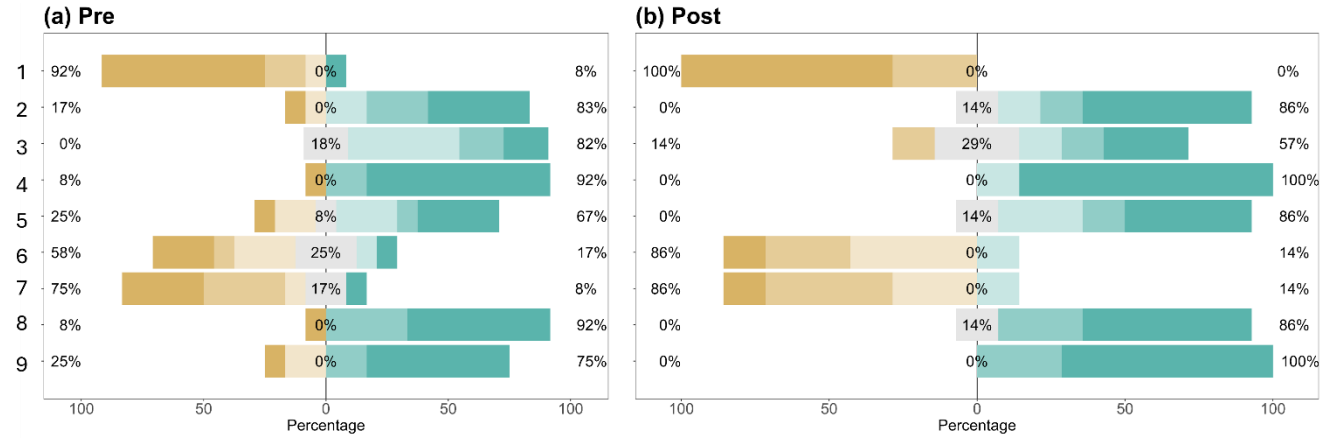

Figure 3: Likert scale data showing responses to research question 2 (Is there a need for social justice in engineering?) before (a) and after (b) completing the module on environmental justice. Survey questions were: 1. The skills in my intended profession are not useful in making the community a better place, 2. People in my intended profession should use their skills to solve social problems, 3. Helping others is a central message in my intended major, 4. People in my intended profession can have a positive impact on society, 5. I feel called to serve others through my intended profession, 6. I view my intended profession and community service work as unconnected, 7. Service should not be an expected part of my intended profession, 8. It is important for people in my intended profession to consider the potential broader impacts of technical solutions to problems, 9. People in my intended profession have contributed greatly to fixing problems in the world

3.3 The module motivated students towards service

The module made the students realize that their efforts can make a difference in the community and in society. One of the major reasons why people shy away from service is the notion that they are one person and so their contributions are minimal to society. To address this fallacy, the author incorporated case studies highlighting instances where a handful of people, or in some cases just one person, successfully fought for their communities' rights. Success stories such as the fight of the women in the Chipko movement and the Love Canal tragedy [22], [23], and about Latino communities pushing back against landfill construction in their neighborhoods [24] were presented to the students. Students were assigned to investigate these cases, examining the historical context, motivating factors behind the activism, the strategies employed to amplify marginalized voices, and the tangible outcomes achieved. Following their research, students engaged in a structured class discussion and produced reports summarizing their findings. This pedagogical approach helped to make the students realize that their contributions matter. It informed the students that there are ways to make their voices heard and their work does help make a difference to their communities and society. Therefore, after completing the module, all of the respondents agreed that they could make a difference in the community (**Figure 4**), whereas 9% of the respondents disagreed with the statement before starting the module (Survey question 15). Additionally, the percentage of respondents who believed they could have an impact on solving the problems that their communities face and that their contribution to society will make a difference, increased from 82% to 86% (Survey question 7 and 3). This was not limited to communities in the US only, as more respondents disagreed that they cannot have an impact on solving problems that underserved communities face internationally (up from 73% to 86%, (Survey question 1).

The realization of the existence of vulnerable groups and the significance of one's efforts motivated the students toward service and social justice. Students engaging in social service greatly help remove social and economic inequalities [25], [26]. By showing the increased risks of the socially and economically weaker communities to environmental hazards, and their inability to access quality healthcare, this module inspired students to help their local communities. All respondents agreed that they should help people less fortunate with their needs and problems (Survey question 2). More respondents (up from 83% to 86%) agree on the importance of using the skills gained from their profession to help others (Survey question 12) and all the respondents pledged to use their skills gained from their profession to help others (Survey question 13). More respondents also agreed that they will be involved in social justice for the rest of their lives (up from 58% to 71%, Survey question 10). This is in agreement with previous studies which observed that major motivations for service include learning about poverty, a desire to help underprivileged people, forming relationships with community partners, and a sense of responsibility towards the community [27], [28]. Interestingly, more respondents were open to changing the design or recommendation based on community feedback (Survey question 14). This is contrary to what was observed for Survey Question 8 in Figure 3, where fewer respondents agreed that engineering people should consider the broader impacts of technical solutions. Therefore, although the students were less open to checking the broader impacts of engineering projects, they were open to community feedback and were willing to modify engineering designs accordingly.

Equally, although the module motivated them towards service, the students did not feel obligated to serve society. Less respondents agreed that they felt an obligation to contribute to

society (down from 73% to 57%, Survey question 4). Additionally, fewer respondents felt it was important to participate in community service (down from 82% to 71%, Survey question 6), to use their skills to serve the greater community (down from 92% to 86%, Survey question 9), and to use their professional abilities to serve the community (down from 92% to 71%, Survey question 11). Fewer respondents also felt that it was their responsibility to take some real measures to help others in need (down from 73% to 71%, Survey question 5) or do something about improving society (down from 73% to 57%, Survey question 8). One of the reasons for this could be a lack of working closely with community partners and a lack of integration of the course with actual community service experience [28]. Therefore, to increase motivation, future studies may require more hands-on research projects where students work with the communities they want to serve. Notably, similar to Survey Question 8 in Figure 3, the respondents did not disagree with these statements. Instead, they adopted a neutral stance on the questions, indicating that they were still open to service without the compulsion.

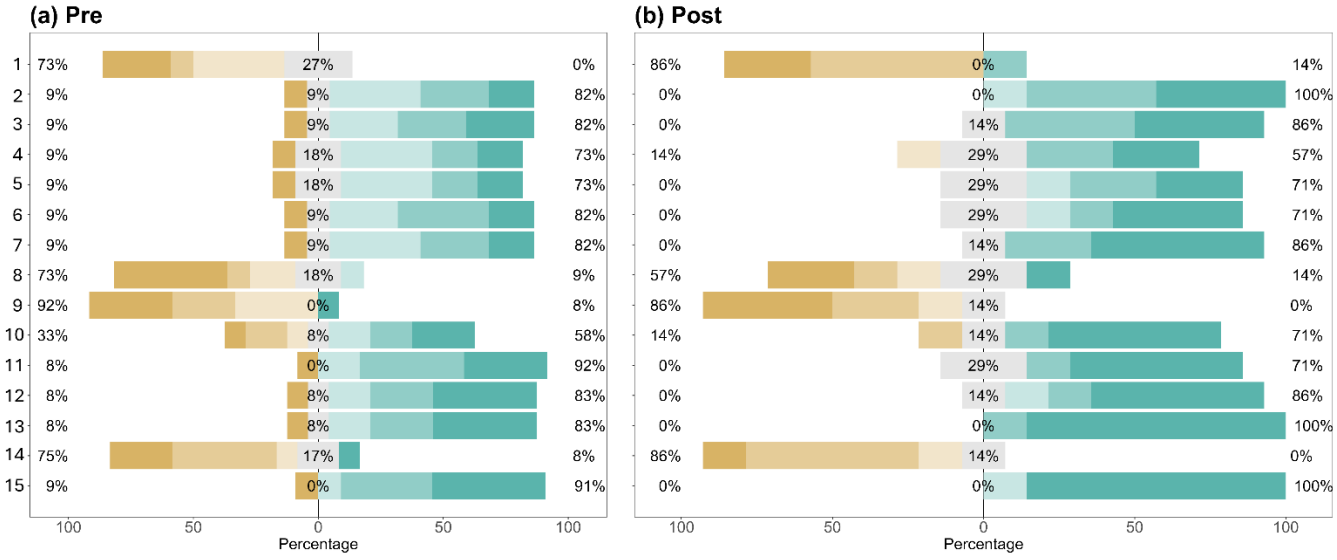

Figure 4: Likert scale data showing responses to research question 3 (Is it important for me to help people from disadvantaged communities?) before (a) and after (b) completing the module on environmental justice. Survey questions were: 1. I cannot have an impact on solving problems that face underserved communities internationally, 2. I think I should help people who are less fortunate with their needs and problems, 3. My contribution to society will make a real difference, 4. I feel an obligation to contribute to society, 5. It is my responsibility to take some real measures to help others in need, 6. It is important to me to have a sense of contribution and helpfulness through participating in community service, 7. I can have an impact on solving problems that face my local community, 8. It is not my responsibility to do something about improving society, 9. I do not think it is important to use skills gained from my intended profession to serve the greater community, 10. I believe that I will be involved in social justice issues for the rest of my life, 11. It is important to use my professional abilities to provide a useful service to the community, 12. I think it is important to use the skills gained from my intended profession to serve others, 13. I will use the skills gained from my intended profession to help others, 14. I would not change a design or recommendations because they conflicted with community feedback, 15. I can make a difference in my community.

4 Conclusion and Limitations

This study investigated the effect of adding a module on environmental justice to a required junior level course on environmental engineering on the students' perspective on social justice and service. Three research questions were explored: 1) Is there a need for environmental social justice? 2) Is there a need for social justice in engineering? 3) Is it important for me to help people from disadvantaged communities? The students responded to the Generalized Professional Responsibility Assessment before starting the module and again after completing the module, and the change in responses were recorded. Specific questions in the Assessment were selected and grouped into the three research questions for analysis. The following observations were made:

1. Students had an idea of the need for social justice in the US before working on the module, but the module affirmed their beliefs.

2. The module made the students realize the importance of engineering in society and the responsibility that engineers have in promoting a just society.

3. The module helped students realize that their work can make a difference in their communities and society in general. This motivated them to use the skills and professional abilities that they learned in engineering to help people not only in their communities, but in the nation and internationally as well. However, the students did not feel obligated to social service. To combat this, future environmental justice modules should have students working closely with communities.

Therefore, teaching environmental justice in civil engineering curriculum develops a feeling of responsibility to students as future engineers and motivates them to work on helping people and communities who are less fortunate than them. This approach equips them to combat inequities and actively contributes to achieving environmental and social justice.

Although the study yielded promising results, it is limited by the sample size. The study will be continued in future classes as well as environmental engineering courses in other universities to get a larger sample size to evaluate. In addition, the GPRA will be supplemented with additional evaluation tools including written testimonials, course evaluations, and specialized surveys focused on environmental justice.

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