

## PAPER

# Understandings of Social Justice in Engineering Education

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## ABSTRACT

Despite being a core element in the engineers' code of ethics, social justice is rarely discussed in engineering classrooms. International service-learning experiences offer opportunities to explore complex, socially relevant problems. Seven participants' responses to surveys administered before and after an engineering design experience were analyzed to assess the participants' understanding of social justice. Employing Leydons and Lucena's six social justice criteria as a framework, we found all six criteria present in the participants' responses, with all participants demonstrating contextual listening. Four participants' responses aligned with all six criteria, indicating their desire to discuss social justice topics. Seven sub-themes were identified and include empathy, interest in people and culture, human-centered design, root cases, limited resources, personal agency, and the role of the engineering profession. The participants advocated for human-centered design, but their language did not include the community as co-designers. Also, the participants identified the complex political and economic nature of real-world problems, and they developed their engineering identities through the experience. This exploratory study seeks to encourage engineering educators to facilitate social justice discussions and to offer ill-structured, real-world problems to students.

## KEYWORDS

social justice, engineering education, design, service-learning, international

## 1 INTRODUCTION

Engineering educational frameworks prioritize technical problem-solving with little emphasis on broader social responsibilities. This focus on the technical domain fosters what Cech [1] describes as "cultural disengagement," where social and ethical considerations are marginalized. As a result, engineering students often struggle to understand concepts of social justice and perceive these concerns as peripheral or secondary to their technical expertise [2]. As global challenges become increasingly complex, preparing engineers to think critically about social implications in engineering development is more urgent than ever.

Service-learning design projects are one type of experiential learning that fosters civic responsibility and provides a service to the community while students acquire

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knowledge [3]. These programs have the potential to address gaps in traditional engineering education, which can overlook social responsibility, warranting further study.

This paper examines the effects of a service-learning experience in Honduras from the perspectives of seven engineering students from the Faculty of Sustainable Design Engineering of the University of Prince Edward Island. Specifically, we seek to understand how the experience influenced their views on social justice, as well as their sense of responsibility as engineers. Drawing on pre- and post-survey responses, this exploratory study evaluates changes in students' attitudes using Leydens and Lucena's [4] six-point social justice framework to address the following research questions:

1. How do engineering students' definitions of social justice change through an international service-learning experience?
2. Do engineering students demonstrate the six social justice criteria in their responses following their international service-learning experience?

By analyzing shifts in participants' understandings of social justice, this study contributes to the engineering education literature on preparing students to be socially aware and active.

### 1.1 Positionality statement and land acknowledgement

Following the example of Secules et al. [5], we offer a positionality statement for the two authors, as their background and experiences impact how the data were interpreted and the conclusions reached. Particularly necessary in social justice research, standardizing the inclusion of positionality statements documents instances of privilege and seeks to uplift voices that have been historically neglected.

The first author, a fifth-year engineering student, noticed how little social justice is covered in the curriculum. Growing up in India and now studying in Canada adds to the richness of her perspectives on social justice. She hopes to inspire engineering educators and students to openly discuss and include social justice in and outside classrooms. The second author is an aerospace engineer of European descent who has led and participated in numerous service-learning projects, both domestically and internationally. In her engineering design courses, she attempts to inject social justice and ethical discussions, though she, too, believes this is a gap in the curriculum.

This research was collected and analyzed on the unceded and traditional lands of the Mi'kmaq people. Also, the participants travelled to the territory of the Lenca people.

### 1.2 Social justice in engineering pedagogy

In the face of complex social and environmental issues, educators call for systemic transformation of engineering education. Before moving to what the transformation might entail, let us first examine problems within traditional engineering education. First, critical perspectives argue that traditional engineering education fosters a dualistic sense of knowledge, separating technical and non-technical domains [6], [7]. Further, the ideology of depoliticization claims that the non-technical issues are irrelevant to "real" engineering education [1]. This hierarchical structure of knowledge is reinforced through a prioritization of theory-based courses over

practical design courses, which foster professional development skills, interpersonal communication, and teamwork.

Second, engineering education can be disconnected from arts and humanities domains. The separation in engineering education has reduced students' exposure to a broad knowledge base and has valued math and physical sciences over social sciences [8], [9]. Despite the "silo"-ing effect in the educational system, engineers need to learn how to have transdisciplinary conversations to be able to tackle contemporary challenges [10], [11].

Third, engineering education does not provide ample chances to learn from failures, nor does it prioritize reflexivity and contextualization to understand and address injustices of engineering practice [9]. In fact, reflection in engineering education is described as "absent or accidental" [12]. Learning from failure and differentiating productive failures from unproductive successes are important parts of humanitarian action [13]. In subjects such as social sciences, individuals may reflect on and learn from historical events to identify past "failures" and associated resolutions. Unfortunately, engineering education does not emphasize historical developments to the same magnitude. Engineering students could benefit from regular examination of historic events, the impact of engineers in relation to social justice topics, and engineers' responsibility to protect the public. For example, in the late 1990s, engineers installed tube wells in Bangladesh but dismissed local warnings about "devil's water." The engineering solution was well-planned and executed with many sustainable features. However, by ignoring the community's input, as many as 77 million Bangladeshi people were exposed to high arsenic in drinking water and suffered health consequences [14].

Though ABET accreditation criteria [15] specify necessary learning outcomes for students that go beyond the technical requirements, Chan [16] argues that additional learning outcomes could better fulfill the human dimension, caring, and learning how to learn. Rubrics such as in [17] suggest ways to assess students' understandings of the global, economic, environmental, and societal impacts of their design, but they do not address social justice considerations.

As these issues with traditional engineering are brought forth, the question arises; are engineers set to meet today's challenges? Despite the many technical engineering achievements and advancements, it is humbling that engineering practice has historically caused social harm and environmental degradation [10]. Additionally, after engineering solutions have been implemented, societal problems can arise [18], such as in the Bangladesh pipeline.

In the "real-world," problems are often ill-structured and multi-faceted and can have conflicting goals, but engineering education generally presents bounded, simplistic problems [19]. Thus, engineers can be thrust into issues that are beyond their ethical training. The code of ethics for engineers has been criticized as "disaster ethics," concerned only with extreme situations [20]. The code and most case studies fail to provide students with examples they are more likely to experience in practice.

Pedagogical researchers identify these challenges and propose the need for systemic transformation [21], [22]. Herkert [23] calls for educators to shift from "microethics" to "macroethics," where ethical considerations extend beyond individual or internal professional relations to encompass broader social responsibility. Scholars argue that engineering transformation can only be achieved through explicit attention to political engagement and social justice. This means questioning what knowledge is valued, who the collaborators are in an engineering project, and what the harms and benefits are for everyone involved [6], [24]. The rise of complexity engineering in recent years encourages engineers to embrace ambiguity and open another layer of complexity in engineering solutions [8].

Researchers have discussed the importance of social justice in reshaping engineering programs to shift the mindset from offering charity to empowering communities [25]. Social justice is considered a tool for the decolonization of engineering education [26]. While the social justice approach is taken into account for solving frequent isolated issues of community engagement, discrimination, and inequity, educators hesitate to acknowledge social justice as a key pillar of engineering education and practice. This is especially troubling since innate issues of sustainability provide ample opportunity for the adoption of social justice principles [9]. In addition, many universities have adopted service-oriented frameworks, such as peace engineering, humanitarian engineering, or engineering for social justice. Pedagogical strategies have been proposed to incorporate social justice into learning objectives and simulation projects for a technical simulation course [27]. However, endeavors are limited to isolated actions [8].

## 2 MATERIALS AND METHODS

### 2.1 Methodological framework

Acknowledging the importance of social justice in engineering, in this paper we adopt the principles of engineering for social justice by Leydens and Lucena [4]. They define social justice in engineering as “practices that strive to enhance human capabilities through an equitable distribution of opportunities and resources while reducing imposed risks and harms” [4]. Expressed as a framework, the six social justice criteria they propose are 1) Listening contextually, 2) Identifying structural conditions, 3) Acknowledging political agency/mobilizing power, 4) Increasing opportunities and resources, 5) Reducing imposed risks and harms, and 6) Enhancing human capabilities.

The six social justice criteria in engineering have been used in intercultural contexts to address the challenges associated with engineers’ community engagement [28]. Though particularly relevant within an engineering setting, the framework can also be used in fields beyond engineering, such as business administration. The need for such a framework is vital in the engineering context because social justice can be conflated with ideals such as equity and fairness, rather than being practical, actionable steps.

### 2.2 Participants

Reviewed by an institutional ethics review board, this study surveyed first-through fourth-year Sustainable Design Engineering students before and after an international service-learning experience. The participants traveled to Honduras for an international service learning experience in February 2023. They collaborated with Honduran professional engineers and community members in a rural location to understand the community’s water needs. At the end of the ten-day trip, participants provided a report summarizing the water survey, material needs, and estimated cost for the community to install piping to access clean water.

This paper documents one part of a larger exploratory study that investigated barriers and motivations of students attending an international humanitarian engineering experience. The purposive sample includes seven participants who completed the post-survey, six of whom also completed the pre-survey. Participation was voluntary and completed online. Two participants identify as women, and five participants identify as men. One participant identifies as a racialized minority. As this is a qualitative study, results are not intended to be generalizable, and thus the sample is not representative of the greater engineering student population.

## 2.3 Instrument

Consisting primarily of short-response questions, there were 20 items on both the pre- and post-survey, 16 additional items on the pre-survey, and 35 additional items on the post-survey for a total of 91 questions. For the purposes of this study, only the 17 items shown in Table 1 were reviewed, as they provided information on the participants' understanding of social justice. The first two items address the first research question on whether the participants' definition of social justice changes as a result of the experience. The next 15 items address the second research question on whether participants demonstrated the six social justice criteria during their experience and thus focus on the post-survey. The survey items do not directly map to the six criteria of social justice; rather, this framework was used to review the data.

**Table 1.** Social justice instrument items

Research Question	Item Wording	On Pre-Survey	On Post-Survey
1	Define social justice.	x	x
1	How appropriate is it for practicing engineers to consider social justice when designing engineering solutions? Explain.	x	x
2	What was your interest in going on this trip?	x	
2	Has this experience changed how you feel about engineering?		x
2	What was your favorite part of the trip?		x
2	What did you learn during the trip?		x
2	What were the most useful skills that you used/gained /developed?		x
2	What was your biggest worry during this trip?		x
2	What was the biggest misconception that you had (something you expected that was different)?		x
2	Did you notice any differences between how engineering is practiced in Honduras as compared to Canada?		x
2	Who were stakeholders for the project?		x
2	Do you consider the design successful?		x
2	What did you learn which you did not previously know, about the social impacts of engineering?		x
2	What did you learn which you did not previously know about social justice in engineering?		x
2	What was your role in the project		x
2	Describe any leadership roles you had at any point: while planning for the trip, during the trip, or after.		x
2	Describe a design project that you worked on while in Honduras.		x

The data were reviewed through a qualitative consideration of the responses. Some responses were richer, while other responses were sparse, particularly for research question one, which analyzed fewer items. For research question two, we recursively reviewed the data to see if there was documentation of each of the six social justice criteria. Then, the responses for each criterion were again reviewed to determine whether there were sub-themes in the responses. We reviewed sub-themes against the literature, particularly [4], and performed one more iteration of the results. Triangulation of data was provided by having two investigators review data and compare findings to the literature.

### 3 RESULTS

This section will address the two research questions, in order.

#### 3.1 Question 1. How do engineering students' definitions of social justice change through an international service-learning experience?

To answer the research question of how seven participants define social justice, we compared the pre- and post-responses to the item "What is Social Justice?" Among the seven participants, only four responded in a descriptive manner. The remaining three contributors chose to answer in value statements rather than descriptive definitions. For example, one participant described social justice as "*essential*" before the experience and "*important in a world where injustice is significant*" after the experience, demonstrating growth in understanding but still not providing a definition.

Focusing on the four participants who provided longer definitions of social justice, their descriptive responses are shown in Table 2. Recognizing that four brief survey responses do not provide a wealth of data to analyze, we present this as a foundation of the participants' beliefs and acknowledge the limitation.

**Table 2.** Definitions of social justice in the pre- and post-surveys

Participant	Pre-Survey Definition	Post-Survey Definition
A	"The way of measuring if people have access to basic living requirements and rights"	"Fairness for all"
B	"Assuring equality"	"Treating everyone fairly and constantly learning about different cultures to be socially competent"
C	"People performing fair equitable practices as of paramount importance"	"Social justice is creating an equitable playing field for everyone"
D		"Social justice diversified opportunities that allow equity and inclusion"

**Leydons and Lucena definition [4]:** "Practices that strive to enhance human capabilities through an equitable distribution of opportunities and resources while reducing imposed risks and harms"

Participant B demonstrates a dramatic development in their definition of social justice. Initially, they provided a general definition for social justice of "*Assuring equity.*" After the experience, their definition is more descriptive, as it relays an acknowledgment of their civic responsibility to continuously develop their social competency. Additionally, they identify their specific role and responsibility

to work towards social justice. The remaining three responses relay participants' understanding of social justice as related to issues of fairness, equity, and inclusion. Compared to the richness of the Leydons and Lucena [4] definition of social justice, these high-level definitions indicate that more discussion is warranted for students attending international service-learning experiences to explore their individual responsibility for social justice.

To further probe the participants' personal connection to social justice, an additional social justice item was analyzed to address this research question: "How appropriate is it to include social justice in engineering practice?" In the post-survey, all seven participants responded with fervor that it was appropriate and necessary. Participant A explained; "Yes, it goes on the ethics of engineering and helping others in need." One participant thought, "It is very appropriate for practicing engineers to consider social justice when designing engineering solutions because they design for the public and its interests/needs above all else." These statements show that the participants are committed to social justice. By comparing their responses to the two questions, it is notable that participants speak theoretically about social justice and do not include themselves in the definitions.

### 3.2 Question 2. Do engineering students demonstrate the six social justice criteria in their responses following their international service-learning experience?

A recursive analysis of the 15 post-survey item responses by the seven participants resulted in seven sub-themes for three social justice criteria. The remaining four social justice criteria summarized the responses adequately and did not require sub-themes. Between three and seven participants' responses were associated with each sub-theme or criteria, as shown in parentheses in Table 3. Criteria 1 was the most represented with seven participant responses, while criteria 5 was the least represented with four responses. Examining how many criteria were present in each participant's response, all six criteria were present in four participants' responses. Five criteria were apparent in one participant's responses, and the remaining two participants' responses aligned with only two criteria.

**Listening contextually (Criteria 1).** According to Lucena et al. [29], contextual listening "facilitates meaning making, enhances human potential, and helps foster community-supported change." It is listening while seeking an understanding of the speaker. All seven participants demonstrated contextual listening in at least one response, and three sub-themes were identified: *empathy*, *interest in people and culture*, and *human-centered design*.

Three of the seven participants highlighted *empathy* as an essential skill they developed during the experience. As one participant explained, "This experience has notably enhanced my empathetic abilities, which I believe hold immense significance in our interconnected world." Empathy is a necessary part of listening with a desire to understand the other. Specifically, perspective-taking is a vital part of the empathetic process [30] and can cultivate students' design skills.

Six participants demonstrated an *interest in the people and culture*, as they described getting to know the Honduran people as their favorite part of the experience. The participants' cultural humility and desire for connection with the community signify starting points for contextual listening and form the basis of reciprocal partnership. One participant commented, "My favourite part was interacting with the children of the small communities," exemplifying how cross-cultural interactions are memorable.

Two participants exhibited an understanding of *human-centered design* through their “*need to know who you are designing for.*” They described the need to overcome language and cultural barriers, defining the importance of learning more about the people “*who will be using what you design.*” Listening contextually is a key element of human-centered design, so it is not surprising that participants identified being able to produce better designs through enhanced communication and understanding of users.

**Table 3.** Six social justice criteria and number of participants for each sub-theme

Social Justice Criteria Sub-Theme (# Partic.)	Excerpts
<b>1. Listening Contextually Empathy</b> (4)	“[I learned] the crucial requirement for engineers to possess empathic abilities, particularly when serving impoverished communities. I only wish I could have spent more time there cultivating my global transformational leadership skills and civic mindset while positively impacting said communities.”
<i>Interest in people and culture</i> (6)	“Every single person there showed so much interest in us and who we are and what we were like. We wanted to know the same things back. The people that we got to know may not be wealthy financially, but they are so wealthy in so many other ways, they have family, community, culture, dance, food, laughter and so much more that is just so rich in its own way.”
<i>Human-centered design</i> (3)	“You need to know who you are designing for and who will be using what you design.”
<b>2. Identifying Structural Conditions</b> <i>Root causes</i> (4)	“Political changes (even municipal) can effect the outcome ... As the community had an internal fight about land deeds during our presentation, it will likely never be implemented.”
<i>Limited resources</i> (4)	“Working for a national organization now [in Canada], budget really is not a concern until it gets into the tens of thousands. In Honduras [budget] was the biggest factor”
<b>3. Acknowledging Political Agency</b> <i>Personal agency</i> (3)	“[The experience] provided me with an opportunity to become even more passionate about these things and expanding my future horizons with what I will do and who I will help.”
<i>Role of engineering profession</i> (4)	“We have a significant opportunity to use the positives of the position of authority, power, knowledge and professionalism an engineer holds to make change and make a difference.”
<b>4. Increasing Opportunities and Resources</b> (6)	“We initially understood the problem, mapped out the system, designed it using a piping software and optimization, budgeted, and presented it to the community.”
<b>5. Reducing Imposed Risks and Harms</b> (4)	“All designs have implications and the effects on the stakeholders should be evaluated.”
<b>6. Enhancing Human Capabilities</b> (5)	“Social justice is no small thing and must always be kept in mind when working on a project. Even though a proposed design may seem ideal, it will not always benefit everyone equally/fairly”

**Identifying structural conditions (Criteria 2).** Five participants identified “economic, cultural, or other conditions that enable or constrain community aspirations” [4]. In the first sub-theme, four participants discussed the *root causes* that could constrain a community’s ability to flourish, such as access to technology and governmental support. Participants’ identification of systemic constraints indicates a deeper understanding of social justice. Rather than stating the more visible problem the participants were asked to address, namely access to clean water, they discussed possible causes for it.

In the second sub-theme, *limited resources*, four participants described differing economic and material availability between the two countries, Canada and Honduras. As one participant explained,

*“In Canada, there’s almost an unlimited amount of options for materials to use but in Honduras there is only a few options...The project does feel unfinished though in the sense that it might not be used as the community has to generate funding for it and it still has to be built.”*

Here, money and material availability are constrained resources for the community, which could jeopardize the project’s success.

**Acknowledging political agency (Criteria 3).** Once the structural barriers are identified, as in the previous criteria, the next social justice criteria are acknowledging political agency. “[B]oth within and outside the community, diverse amounts and forms of social power exist” [4]. Recognizing one’s own ability to effect change is an empowering step to taking action. Six participants acknowledged their agency in two sub-themes: *personal agency* and the *role of engineering profession*. Notably absent in the responses is a recognition of the community members’ agency.

By acknowledging their *personal agency*, four participants recognized their own responsibility and ability to respond to social justice challenges. As one participant described, *“You may be only one gear but they need you to keep moving.”* This participant demonstrates their awareness of their agency through the act of reflection, reinforcing the ability to reflect as essential in realizing one’s own power.

Next, four participants extended their personal agency to a recognition of the *role of the engineering profession* in creating positive change. For example, one participant explained, *“it puts into perspective the importance of engineering, and the power it has to change lives. I feel more inclined to work hard in engineering.”* Through their reflection on political agency and inequality, this participant was motivated to work harder in engineering, thus strengthening their engineering identity. Additionally, this sub-theme reveals participants’ recognition of the engineer’s code of ethics to hold paramount the safety, health, and welfare of the public.

**Increasing opportunities and resources (Criteria 4).** The definition of social justice demands an “equitable distribution of opportunities and resources” [4]. On an international service-learning experience to increase access to clean water, all of the participants were inherently working towards this social justice criteria. However, only six of the seven participants provided descriptions of the project and desire to increase access to water. Curiously, one participant did not mention the design and provided shallow responses to most items. It was also noticed that the six participants did not describe collaboration with the community in the design process. For example, one participant explained, *“We mapped out the community, made online simulations, came up with a materials list and cost breakdown, and presented our proposed design to the community.”* The word “presented” excludes the involvement of the community in the design process. The choice of the language indicates a user-centered design process rather than a more inclusive co-design process that involves the community partner at every stage. The participants acknowledge the community members’ opinions, but do not consider them to be design partners. Additionally, the participants did not mention increasing opportunities and resources to address the barriers they identified in criteria 2. Though admittedly, the survey covered many items and responses were designed to be short, it is interesting that this was not addressed by any participants.

**Reducing imposed risks and harms (Criteria 5).** Four participants’ responses addressed “those risks and harms unwittingly imposed on users of a product or

service” [4]. Their descriptions are not the risks associated with their design, but instead two participants described the theoretical need to “*Stop and think about who or what you’re doing or planning is affecting.*” However, the design experience did not proceed beyond the ideation phase, so the participants did not have a chance to prototype or delve into the negative impacts of their design.

Two participants described the risks with the current system, necessitating the design. As one participant explained about the water system, “*The previous system had failed and broken, and community members needed to climb to the top to access water daily.*” Similarly, a participant stated that building eco-stoves “*allow the homeowners to cook safely on a reliable appliance.*” The statement points to the increased reliability and safety of the eco-stoves but does not show critical reflection on risks and harms of the new system on the community.

**Enhancing human capabilities (Criteria 6).** The first five social justice criteria are practices that ideally lead toward the sixth criteria of enhancing human capabilities, where the term capability is defined as “positive freedoms that people have to enjoy” [4]. In an engineering design setting, by empathizing, identifying barriers, acknowledging personal agency, increasing opportunities and reducing risks, a design should enhance a person’s life. For this research, this sixth criteria were present in five participants’ responses. They recognized the necessary role of social justice in engineering and acknowledged the complexity inherent in design to provide equitable solutions. For example, one participant described:

*“We need to make positive changes and to do that we need to consider all of the social injustices and actively put motions and designs into action where there is the least possible disadvantage to anyone or anything...every single task impacts so many different factors.”*

This participant recognized their responsibility to act and desired to minimize the harm. Similarly, a participant realized their agency and connected it to their engineering identity, “*I saw how unequal the world was ... how engineering plays a crucial role in social justice as it can create and provide solutions.*” The international service-learning experience provided an opportunity for the students to reflect on their identity, their responsibility, and their future profession.

## 4 DISCUSSION

The two research questions reveal the following four discussion points:

### 4.1 Community involvement in design

Contextual listening, the most represented of the criteria, necessitates empathy, understanding, and most importantly co-defining the problem with the community [7]. Participants described communicating with the people of the community with empathy and interest. Six of the seven participants indicated that interacting with the community was their favorite part of the experience. Also, in the human-centered design sub-theme, three participants reflected on how the community contributed to problem-solving.

However, these responses did not provide any evidence of defining the problem with the community. Similarly, the community members are not included in criteria

3 or 4, as participants did not comment on the community members' agency or involvement throughout in the design process. This points to an important result that participants engaged in human-centered design, but not co-design, wherein the community is included in all stages of the design process as co-designers [31]. In this experience, the community were considered as part of the design process, but not included as co-designers. According to Zoltowski, Oakes, and Cardella, there are seven categories of how students experience human-centered design ranging from technology-centered design to empathic design. From the responses, most participants in this study are in the second-lowest category of service, where the design strategies are only to achieve goals [32]. In the context of service-learning, social justice can be defined by the level of community involvement in terms of reciprocity, mutuality, personal humility, and mutual learning between stakeholders [33]. Thus, engineering educators preparing students for an international service-learning experience could facilitate a discussion on the differences between co-design and humanitarian design. This could influence and enhance the participants' understanding of social justice. Additionally, it would foster community partnership to ensure community partners benefit more from the experience.

#### 4.2 Complex political and economic nature of the problem

The theme of identifying the root causes of the problem in the second criteria reveals that four participants recognized the significant roles of political factors contributing to the challenges faced by the Honduran community. This acknowledgment underscores that social justice issues are not solely technical but are deeply intertwined with political and economic dimensions. Such recognition represents a critical understanding of the multifaceted, complex nature of social justice, particularly within engineering education. Though engineering education practices typically employ a hierarchical preference for technical knowledge and a separation from the humanities [1], [10], these findings indicate students are interested in exploring the more complex nature of real-world problems. Furthermore, the finding bolsters the need for experiential projects for students to grapple with these more complex situations rather than the bounded problems found in the university environment, as in [8], [19].

#### 4.3 Engineering identity

In the third criteria, acknowledging political agency, four participants critically reflected on their engineering identity. Additionally, three participants in criteria six integrated social justice into their engineering responsibility, recognizing how their role as engineers can reduce inequity. This result is similar to Reyante's identification that reflection on power and privilege is a "locus of change" to shift students from charity-mindsets that focus on helping to justice-mindsets that seek lasting, systemic change [34]. This important connection can also be seen in how they relate engineering and social justice in the first research question. In these real-world settings, students see first-hand the impacts of poorly-considered designs. Rather than reading a "disaster ethics" case study [20], these experiences allow students to shift towards "macroethics" to consider the broader implications of engineering and their social responsibility [23]. The more they understand about the role of the engineer in society, the better prepared they can be in the workforce when confronted with ethical quandaries.

#### 4.4 Limitations

Limitations of this study include the small sample size and short responses. Though the first question was directly asked to “define social justice,” the second research question was mined from the data. Thus, the sub-themes are framed within the context of the six criteria and not intended to be generalizable. Additionally, reviewing the data for the six criteria instead of directly asking about it could explain the lack of sub-themes for criteria 4–6.

The last three criteria describe the impact of the work that participants did in Honduras, and most responses are about the design process or project’s success. Some participants felt they provided a design of a water system as was intended. However, one participant felt the design was successful, but not the project. These sparse design-centric observations do not align with the empathic, people-centric, reflective responses under contextual listening. Perhaps participants recognized that the nature of the community’s challenges were not merely technical but predominantly political. They understood that systemic inequities were largely driven by resource constraints, particularly financial limitations. However, the participants were unable to address these larger structural issues or directly provide resources to “help” resolve the inequities. This realization likely affected their morale and sense of agency and highlights a critical distinction between social justice initiatives and traditional engineering workplaces. Social justice endeavors demand that participants engage with an added layer of complexities of systemic inequities, including political and economic factors that lie beyond their immediate control. Such complexity can be overwhelming for students, especially within the constrained timeframe and resources of a service-learning program. Faced with these challenges, participants appeared to segregate the technical and social aspects of the project. Some participants sought satisfaction in delivering a technical solution that might work under ideal conditions, while others focused on the social achievements of fostering empathy, communication, and cultural understanding with the community.

The varied responses also reflect the ethically-complex reception of international service-learning experiences in the literature [35]. The experiences have been criticized as providing more benefits to students than to the community, and even as a new form of colonialism to use international communities as a classroom [36]. The experiences are sometimes described “voluntourism” [37]. We acknowledge this moral quandary and hope that our examination of the experience through the lens of the six social justice criteria can provide insight for engineering educators, encouraging them to examine social justice in their classes as well. Experiential opportunities, domestic or international, offer opportunities for students to engage with complex problems in both technical and non-technical domains. This allows students to appreciate the contributions of humanities and social sciences to their education, as this knowledge is necessary for students both in university and when they enter the workforce. When community partners are engaged through co-design with mutuality and respect, all collaborators can benefit.

## 5 CONCLUSION

In this paper, we investigated students’ perspectives on social justice before and after an international service-learning experience. The first research question on how definitions of social justice changed throughout the experience revealed that understandings of social justice were not dramatically altered. Their definitions

revolved around equity, which did not change after the experience. Participants compared the lack of resources of the community to that of their own circumstances and associated this as the main reason for inequity. Although this relation is critical in forming ideas towards social justice, it is a non-reflective and shallow answer. This calls for engineering educators to implement more formal interventions to refine students' definitions of social justice.

In the second research question, each of the six social justice criteria were evident in at least four participants' responses. All participants described listening contextually through their empathy, interest in people and culture, and advocating for human-centered design. In the second criteria, participants identified the root causes and limited resources as structural conditions. In the third criteria, participants acknowledged their personal agency and the role of the engineering profession. The final three criteria were less reflective and primarily design-process or success-oriented. However, that could be due to survey design and the need to recursively search for the data. A future study could survey students on the six criteria directly.

In the international service-learning experience, students developed their engineering identity and grappled with the complex political and economic nature of ill-structured problems. They demonstrated a desire for human-centered design and included the community's desires in the design, but they did not consider them to be co-designers. Though we acknowledge that this exploratory study is limited by the richness of data and coupled with the ethical complexity of international service-learning experiences, these findings indicate a need for engineering educators to facilitate conversations to help students to process the intertwined nature of social justice and engineering in real-world applications.

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