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Navigating Transformational Resistance: Exploring Humanitarian Engineering Students' Capacities for Addressing Systemic Causes of Infrastructure Service Disparities

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Abstract
Students enter Humanitarian Engineering (HE) Graduate programs to address infrastructure service disparities in low-income and marginalized communities. Research has found that HE students and the larger HE field want to address the systemic causes of these disparities. However, there is a shortage of scholarship illustrating students' capacity to do so. Further, the limited scholarship on HE students and systemic change focus on the barriers and failures of students to do so. This study analyzes humanitarian engineering students' aspirations and actions for global infrastructure service improvement. We use the Transformational Resistance Framework (TRF) to characterize moments of motivation, negotiation, struggle, and advocacy to address structural oppression. In doing so, this study explores the potential for Humanitarian Engineering students to act as agents of change in transforming unjust systems of oppression. Specifically, this preliminary study found moments of students demonstrating a strong motivation for social justice, critiquing systems of oppression, and, at times, demonstrating both of these characteristics simultaneously.

Introduction
Practitioners, faculty, and students from the Humanitarian Engineering (HE) field are increasingly interested in addressing the systemic causes of infrastructure service disparities. Humanitarian Engineering (HE) programs often have missions that center on the systemic causes of inequality, such as training graduate engineers to "concern with the unequal and unjust distribution of access to basic services such as water, sanitation, energy, food, transportation, and shelter, and (who) place emphasis on identifying the drivers, determinants, and solutions toward increasing equitable access to reliable services" [1]. Further, HE scholars have encouraged HE students and faculty to focus their efforts on understanding and dismantling the systems that cause poverty and environmental degradation [2].

However, there is a shortage of scholarship that characterizes students' potential and growth in dismantling systems of oppression. Most articles focus on characterizing the barriers and failures of students to address systematic oppression. For example, studies have illustrated how HE-orientated students at times ignore systematic inequality and partake in unhelpful, neocolonial engineering projects [3], [4]. Other studies have illustrated students becoming frustrated and disillusioned by the difficulty of addressing systemic inequality [5].

This shortage of research, combined with the HE field's interest in addressing systematic causes of inequality, illustrates the need for more scholarship that highlights students' capacity to dismantle structures of oppression.

Literature Review
Humanitarian Engineering Education
Humanitarian Engineering (HE) educational programs are growing exponentially globally, from less than two accredited programs in 2000 to over 67 in 2020 [6]. Students entering these programs tend to be socially minded and have a higher population of historically underrepresented minority groups compared to the larger engineering field [7], [8]. These cohorts are enrolling with a passion for addressing modern-day engineering initiatives such as the United Nations Sustainable Development Goals and the National Academy of Engineering's Grand Challenges of Engineering in the 21st century. While HE programs have a variety of names, including community development, technology development, global engineering, and sustainable development, they often share a common interest in improving infrastructure service provision in marginalized communities [6].

At the same time, the engineering field has undergone a period of introspection and 'reckoning' where there is increased interest in understanding and addressing the systemic causes of infrastructure service disparities. Systemic causes of inequality are specific policies, cultures, or norms that combine to perpetuate discrimination, marginalization, and inequality based on factors such as race, gender, sexuality, nationality, or socioeconomic status [9]. Systemic causes of inequality enable socially dominant individuals to maintain their privilege even if they do not have an objective nor partake in purposeful actions to maintain their supremacy [10]. By ignoring systematic oppression in America, engineers have implemented infrastructure (e.g., wastewater treatment centers, bridges, transportation, and energy supply) whose placement and quality perpetuate institutional and environmental racism [11], [12]. Further, engineers have oppressive systems embedded within the field itself, such as *meritocracy,* or that wealth, knowledge, and power are distributed in the world based on merit and hard work [13].

Humanitarian engineering is not immune to this introspection and calls for transformative change. Indeed, opinion pieces, such as "Foreign Aid is Having a Reckoning" and "Black Lives Matter is Also a Reckoning for Foreign Aid and International NGOs," illustrate how discriminatory norms, policies, and cultures within the field itself are being examined [14], [15]. In particular, Scheider and colleagues wrote that HE faculty and students' energy might best be directed at examining and alleviating the systems that lead to dire economic and ecological conditions globally [2]. Indeed, present-day HE mission statements are focused on understanding and addressing drivers or systemic causes of inequality. For example, one mission statement expresses a desire to train students to carry "concern with the unequal and unjust distribution of access to basic services such as water, sanitation, energy, food, transportation, and shelter, and

place emphasis on identifying the drivers, determinants, and solutions toward increasing equitable access to reliable services [1]. Further, HE education often includes literature highlighting the systems causes of inequality such as global debt, transatlantic slavery, lack of reparations, and modern cultural/economic imperialism [16], [17], [18], [19].

However, while calls to address oppression are abundant, there is a dearth of scholarship detailing how to address systemic inequality successfully. For instance, Niles and colleagues [20] found that simply instructing students in the social context of engineering and global inequality in HE education does not guarantee that HE graduates will critique and confront internal or external oppressive systems. Further, Andreotti [3] documented HE-orientated students falling into "thin" global citizenship, in which they carry a charitable benevolence towards others but fail to deeply analyze the historical and political processes that generate infrastructure inequality and that privilege of those enabled to "help." Finally, Schneider and colleagues' [2] review of conference presentations on higher education programs found that engineering educators often attribute engineering project failures to technical, communication, or cultural issues and overlook the oppressive systems that could contribute to a pattern of failures across projects.

Instead, students have expressed frustration with only being shown cases of failure [21] and wanting examples of success stories. HE students have expressed "just wanting to know what to do" when encountering complex ethical and ambiguous questions. Further, without clear answers, they express frustration and disengagement from discussion topics around systematic oppression [5]. Other scholarship has shown students dropping out of engineering spaces when they realize the engineering field's role as oppressors and when they feel they are unable to change this role [22].

Indeed, the majority of HE scholarship on social justice tends to highlight the challenges and barriers associated with developing a critical understanding and actively working towards dismantling systemic causes of inequality and does not highlight examples of when students can successfully acknowledge, critique, or act to address systemic injustice. This focus often overshadows and may not adequately acknowledge students' capacity to engage in such efforts. Further, HE scholars who have begun studying the development of students' ability to identify and alter the structural conditions that cause inequity, or what some call the design-for-justice mindset, have called for studies that look across multiple HE universities and that study students across longer periods or multiple academic semesters [23].

To address the need to showcase how students can recognize and critique social oppression, this research analyzes humanitarian engineering students' aspirations and actions for infrastructure improvement through the Transformational Resistance Framework.

Transformational Resistance Framework

The Transformational Resistance Framework (TRF) was created to emphasize students' ability to be cognizant of, negotiate with, and struggle against systemic oppression, as well as the importance of students partaking in this process in the struggle for a better, more equitable world. TRF came from a branch of resistance scholarship, which argues that students are not passive vessels when learning about the systems that perpetuate social class when being oppressed personally by systemic inequality and when being asked to reproduce these systems. Instead, they have the agency to actively negotiate and struggle with oppressive structures, creating meaning from these interactions. Within resistance scholarship, TRF emphasizes that students not only resist social oppression but also can act in a way that is motivated by social justice or a more just or equitable world [24]. In short, the TRF deduced that students are acting as agents of social transformation as they grow in their ability to critique social oppression and maintain a motivation for social justice.

Figure 1 visualizes transformational resistance by placing the principles of critique of social oppression on the vertical axis and motivation for social justice on the horizontal axis. Accordingly, the Transformational Resistance framework theorizes four quadrants of oppositional behavior: reactive, Conformist, Self-Defeating, and Transformational Resistance.
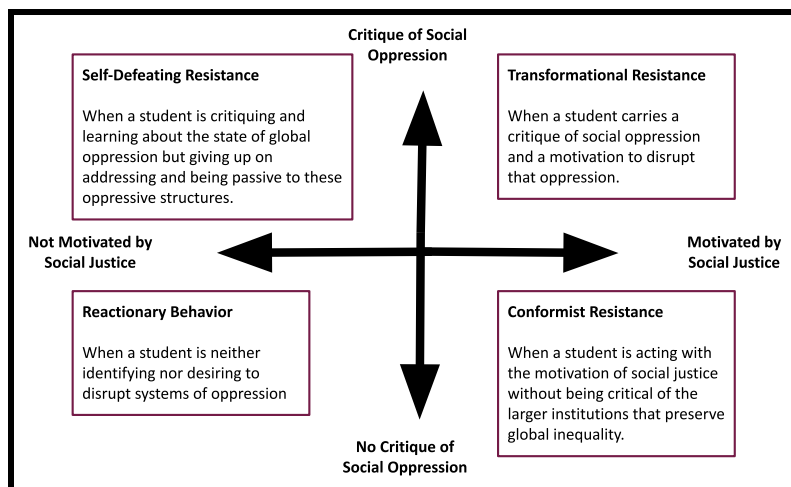

Figure 1: Transformational Resistance Framework

Not being motivated by social justice and not critiquing social oppression (reactionary behavior) is characterized by a student being unable to identify inequitable or culturally incongruent educational systems that are causing personal hardship but still 'fighting back' or being oppositional because of the hardship they are facing. When a student is *motivated by social justice and not critiquing social oppression* (conformist resistance), they may act to address the hardships they and their peers face but continue to be unable to name or address the systems causing those hardships. This could look like a student creating study groups for struggling peers

but not addressing the curriculum and classroom culture that causes their peers to struggle. In contrast, a student performing *not being motivated by social justice but critiquing social oppression (self-defeating resistance)* may be interrogating and deconstructing the systems of oppression and privilege occurring in education systems but is unmotivated to overturn those systems. Here a student may partake in self-harming oppositional behavior such as dropping out of school. Finally, *being motivated by social justice and critiquing social oppression (transformational resistance)* is characterized by a student being critical of the oppressive norms, policies, and cultures around them while carrying a motivation to disrupt those systems. One example would be a student doing well in school so they can get involved in policy to change oppressive systems one day. While conformist, self-defeating, and transformational behavior are all forms of resistance, transformational resistance is often characterized as having the most agency for change because it includes both an awareness of systemic oppression and a desire to change it [24].

The TRF framework was first developed to understand students' survival and resistance to educational systems that promoted their attrition in school and suppressed their expression of thought, such as students of color in the United States (Solorzano and Bernal 2001). Thus, the majority of scholarship describes these quadrants from the experience of students trying to change the systems they are marginalized from and actively oppressed by. We argue the need to characterize socially dominant students by the TRF or, in other words, characterize the potential for students to dismantle systems of oppression that they are privileged to ignore or even benefit from. Indeed, scholars have correlated transformational resistance with socially marginalized students, carrying a strong sense of self, questioning everything with purpose, advocating for themselves and their communities, feeling self-driven, having a heightened awareness about injustices, and having a multicultural and intersectional understanding of the world [25], [26], [27]. Thus, there is immense value in examining if socially dominant students can also carry the valuable traits potentially associated with transformational resistance.

HE programs often train students with a high level of social dominance, including white students and students from high-income countries, to improve infrastructure disparities in communities they are outsiders to. Further, regardless of race and nationality, HE students are trained to address infrastructure service inequality in communities they are not a part of, and thus they carry some level of social dominance. Viewing these socially dominant students' attempts through the TRF lens may shed light on common challenges and ways in which students can work towards transforming an oppressive system. Thus, there is a need to explore the possibility of HE students partaking in transformational resistance despite their inherent level of social dominance. In this preliminary exploration, we ask how HE students are resisting social oppression by asking:

How are HE students critiquing social oppression and being motivated for social justice?

By exploring this question, we hope to determine examples of when students are able to enact social justice in engineering and ways in which the TR framework may be employed in the field of engineering education.

Methods

To explore this question and framework, we interviewed 21 students who were enrolled in seven graduate Humanitarian Engineering programs (three students per program). Using processes outlined in IRB 21-0207, these students were recruited through email advertisements from program directors and professors to their respective HE cohorts. Students carried varying ethnic identities, ages, nationalities, and privileges and were at different stages of their graduate education.

We conducted semi-structured interviews centered around students providing robust and rich personal narratives that detailed their career aspirations and ongoing projects as an HE graduate student. Students were interviewed four times over a two-year time period. Interview guides consisted of three groups of interview questions related to a) students' career goals, b) students' understanding of systematic oppression c) their motivation and personal goals toward social justice. For example, we asked students to describe their current career goals and the story of what led them to their current career goals, their self-efficacy in personally advocating for equality, and the expectation that HE institutions can make progress toward equality.

Audio recordings were transcribed using the software Trint and individually reviewed for accuracy [28]. Interviews were then imported into the qualitative coding software NVivo to be coded deductively into the principles of transformational resistance defined in Table 1 [29].

Critique of social oppression	Critique of structures, including policy, norms, and culture, that perpetuate discrimination, marginalization, and inequality based on factors such as race, gender, sexuality, nationality, or socioeconomic status (Lindsay, 2023).
Motivation for social justice	A motivation for a more just or equitable world

Table 1: Definitions of Social Justice and Social Oppression

Using these codes, we looked for instances of students 1) critiquing social oppression 2) being motivated for social justice and 3) both critiquing social oppression and being motivated for social justice.

For example, one student indicated, "I am being wary of being an extractive researcher, making sure that (my community partners) have something to gain from this work that we're both doing together. One thing I am worried about, is (...) should they be compensated for the time it may

take to scan handwritten documents (...) And I mean, I'll even pay them out of pocket for that." This passage was coded for both critique of social oppression (the student was critical of extractive research) and motivation for social justice (the student described a motivation to work against the norm of extractive research), and thus, fell under the principles of transformational resistance. Coding was discussed with all researchers, following a collaborative coding process [30].

Student motivation for social justice
All students (21/21), at one point discussed a motivation for social justice shaping their career aspirations and actions. In several instances, students expressed a commitment to enhancing infrastructure service provision in low-resource or marginalized communities that was driven by a broader vision for a more equal and just world. One participant shared:

I guess (I have) a sense of equity and solidarity with the global population. Maybe because I did the Peace Corps and kind of lived in a situation like that. It's hard to forget that there are people who don't have running water and a safe place to go to the toilet. So I think that's my motivation.

This participant articulates a sense of solidarity with the global population facing challenges in accessing infrastructure services. They highlight their ongoing motivation for equity, which stems from their personal experiences in a low-resource community.

Another participant discussed how the resilience and strength of low-income communities fuel her motivation to address infrastructure injustices. She explained:

Honestly, I'm very angry at a lot of injustices in the world. I think there are so many people that deserve better. I have a lot of privilege that I've not earned. So I think it's genuinely my responsibility to work on injustices that I see that I'm able to tackle.[...] *I'm really inspired by a lot of people's strength and resilience. Working in Latin America, I worked in a couple of underserved communities, and* [there are] *just people that are beautiful, that are trying to uplift their communities,* [and] *that have this amazing culture that they try to keep alive.*

This student's motivation for social justice is influenced by witnessing community members striving to uplift their communities, coupled with her own family history of coming out of poverty. She also expressed a sense of responsibility to address injustices, which she expresses is inherent to her capacity to address global injustice and the unearned privilege she possesses.

Another participant feels a similar responsibility to work towards social justice, stating:

I feel like it's more of an obligation, it's a responsibility [if] *we're sitting in this position as individuals who have a roof over our heads, clean water to drink, and food to eat. (...) I think*

more people need to act [...] *if enough people and big players don't do anything about it, then the world for our children is not going to be very good.* [...]*I think that developing the world is absolutely imperative for a just and equitable system from a very holistic perspective* [...] *it's really important on a long-term perspective for the way that the world's going to work 30, 40, 60, 100 years down the line.*

The student articulates a sense of obligation to contribute to a more just and equitable global system, recognizing their privilege in terms of infrastructure and resources—having access to shelter, clean water, and food, a luxury not shared by all. Furthermore, they emphasize the importance of more people working towards this goal, deeming a fair and equitable global system as imperative for the long-term success of the world.

Similarly, the following student expressed a desire for social justice as a way to mitigate forthcoming harms he believes the world will face.

We need to design solutions to help mitigate those impacts, especially considering that they [individuals from low-income countries] *are the least responsible...Part of me is very anti-U.S., we do so many bad things in terms of global inequalities and terrorizing our environment on a global scale. And so* [I'm] *trying to mitigate the environmental impacts on the other end, like in those lower-middle-income countries.*

This student underscores a motivation for a more equitable world due to the perceived harm caused by their high-income country, particularly in terms of the environmental degradation that will affect low-resource communities.

In summary, while the motivations varied among students, this study identified all students at one point expressing a motivation for social justice, often using vocabularies such as justice and equality. While this exploration was not exhaustive in capturing the entirety of students' experiences, we found that students reflected on a spectrum of emotions. These include a sense of solidarity with marginalized populations they once lived with, drawing inspiration from the resilience and strength exhibited by marginalized communities, a sense of obligation to advocate for social justice, and a motivation to rectify the harm their own country has inflicted upon marginalized communities.

Student Critique of Social Oppression
This research underscores that many (17/21) students had instances of critically engaging with social oppression, reflecting on norms, cultures, and policies that perpetuate the discrimination of marginalized populations. For example, one participant in the study voiced concerns about inequitable practices in her international development job, stating:

On many [international development] *teams, you have a U.S. manager director and then you have people from the other countries as lower positions, and it's how it is because of biases. I think people are working to try and change it, but because of the way the policies and forms and all that kind of stuff is set up, it's really, really hard. We had a consultant last year on a project, who was [...] making $38 a day, whereas some people from other countries were making $600 to $800 a day. When you have that kind of disparity on the same contract, it's ridiculous. Like, how can you write a contract like that?*

This student reflects on how a HE firm she worked at had pay disparities between team members based on nationalities and countries of residence. This led to projects where some practitioners were making 20 times more than their co-workers. The student emphasizes that bias may be playing a role in these disparities, as high-status managerial positions often seem to be allocated to practitioners from high-income countries.

Similarly, the following student discusses learning to critique structures in the HE project she is a part of, stating:

I was working with an engineering firm but it was faith-based, and they were Christian and, and I remember we were in this 5K run [...] and there was a guy and I was jogging with him and he said, "I'm with this Muslim organization like could you guys do designs for me?" [...] and he was the first person to kind of push me about (our policy) in any way. And I remember saying, like, "he's Ugandan and he thinks what I'm doing isn't like, good."[...] I was so enraptured with the idea that I was finally getting to do this thing that I'd waited like ten years to do.[...] It had just never occurred to me that you could ask questions about the work

Within this passage, this student, who was involved in a faith-based engineering project, recounted a moment of awakening when prompted by a Muslim community member to question her organization's policy of serving only Christian organizations. This experience equipped her with the ability to critique discriminatory practices within her HE organization, despite how excited she was to get the job after years of working towards the career opportunity.

Students like the one quoted below critiqued widespread or common oppressive practices in HE projects, stating:

One of the biggest issues with these international projects is not promoting autonomy and having the community be involved with the project the whole time. [...] *but right now we've been learning about projects that have failed. So I kind of have a pessimistic outlook right now. I also* [learned that] *the word development is rooted in inequality and promoting the global North's hegemony over the global South.*

Within this passage, the student is critiquing multiple oppressive structures. Initially, the student expresses frustration with the norm of HE projects not promoting autonomy with community partners and adequately involving them within the project process. Additionally, she reflects on the ongoing and larger structure of development, highlighting how development itself perpetuates global inequality.

Similarly, the following student critiques both a common norm in humanitarian engineering work and oppressive systems outside of the engineering field, stating:

One of the conflicts I have around international development [is when] *people working in international development from the global north are just automatically assumed to have a certain level of knowledge because of where we come from,* [further] *I think a lot of resources go into paying us rather than like sending resources to the country that needs it and focusing on hiring people there who are qualified.* [...] *Also when I think about international development, and why it's needed. I think the need comes from colonialism by countries in the Global North, and the continuation of global capitalism, and so trying to work on changing our systems here would have the biggest impact.*

This student critiques a culture of prejudice in HE, where practitioners from the global north are assumed to possess more knowledge, leading to the norm of utilizing resources to hire predominantly from the global north instead of tapping into the available hiring pool in the global south. They also critique large global structures such as colonialism and capitalism for perpetuating global inequality and raise the question of whether international development is equipped to address these overarching oppressive systems.

In summary, we found that HE students are actively critiquing oppressive structures, encompassing policies, norms, and cultures that perpetuate discrimination and contribute to the marginalization of communities. The findings demonstrate that students critically examine HE policies and norms, addressing issues like pay discrepancies based on nationality, HE projects not integrating community desires and autonomy, and HE organizations exhibiting prejudice in their collaborations. Furthermore, the study highlights that students extend their critique to larger global systems of oppression and reflect on systems such as colonialism and capitalism, and the historical goals, causes, and ongoing consequences of international development on marginalized communities.

Transformational Resistance: Student Motivation for Social Justice and Critique of Social Oppression
Finally, this research identified many students (13/21) who, at at least one point, concurrently critiqued social oppression AND expressed motivation for social justice. Within these instances,

students reflect on and analyze norms, cultures, and policies that perpetuate discrimination while also demonstrating a commitment to dismantling these structures.

For example, a student in the study critically examines the limitations in how humanitarian engineering classrooms discuss decolonization and expresses a motivation to move beyond these constraints:

So, for example, in humanitarian aid [class]*, we talk about decolonizing the sector. How can we shift power imbalances, work much more closely with local actors, give them agency, trust them. For me, that's already entirely backward because you're still assuming that humanitarian aid should be top-down, whereas Indigenous studies would challenge this and say, actually Westerners* [...] *The way their colonization works is by trying to process things and dispossess others. When we talk about receivers or beneficiaries of aid often they are treated as possessions, as these numbers, and Indigenous studies challenge that. And Indigenous studies also is very relational. How can we prioritize very meaningful relationships over projects that come and go? And how do we base (projects) on our very local cultures and ways of knowing?*

In this passage, the student underscores how discussions on decolonization within humanitarian engineering class often remain confined to improving power imbalances and relationships between community members and HE practitioners. However, these initiatives tend to be top-down or centralized changes across the sector, which fall short of addressing the goals of decolonization as articulated in Indigenous studies. Indigenous studies emphasize dismantling central control as an integral piece of decolonization, making this perspective within humanitarian engineering a norm that neglects the indigenous goals associated with decolonization. This student's passage also displays a motivation for social justice. Specifically, she expresses a goal to move beyond the popular but constrained view of decolonization within HE spaces and is actively engaging in ongoing learning and reflection through her Indigenous Theory coursework on how to integrate the indigenous perspective in her HE work.

Similarly, the same student critiques a norm within a humanitarian engineering conference that she helps run, recognizing its potential to perpetuate inequality of representation. Subsequently, she outlines proactive steps to counteract this structure:

I was able to be part of the process of reviewing all the abstracts, and I thought that was really great because [I could focus on] *the conference's mission around social justice and ethics in the field of Humanitarian Engineering... and we're able to pick up on what's missing* [from the abstracts]. *For example, we don't have anyone presenting from work in Indigenous communities, and I was able to pose, okay, how can we make sure that we're not excluding such a big group in the* [HE] *sector? It's not like we're going to pull an (indigenous) presenter just for the sake of ticking a box - But we did brainstorm how do we address this* [gap]*? And so we made a call for*

videos from people in the field so we can emphasize indigenous communities through that call this year and make sure we have land recognition at the start of our symposium. So it's not just ticking boxes, I think. I think everyone is very supportive of [this work] *because it's pushing the boundaries of what's considered the standard.*

In this passage, the student critiques the absence of representation of indigenous practitioners in a conference she is helping organize. With this critique, the student challenges an oppressive norm in HE conferences – the overrepresentation of foreign, white, and colonial-government-led HE organizations and practitioners. This overrepresentation could have the consequence of stifling indigenous goals and values, leading to their exclusion from HE agendas, conversations, and network creation within the HE community. This passage is classified as transformational resistance because the student is motivated to disrupt the standard. Specifically, she takes action by advocating for a dedicated call for conference presentations focusing on indigenous practitioners. She introduces a remote and asynchronous platform for conference presentations, thereby lowering the barrier of entry.

Similarly, the following student discovered a norm of her engineering company's sustainability reports, excluding the company's impact on the marginalized communities they interact with. She goes on to articulate her motivation to challenge and disrupt this norm.

If you like read [my internship's] *sustainability report, they do not focus a lot on the people side of things* [...]. *The overall goal of my project was to tie how my company can be a better neighbor to the areas that they're operating. If you look at the makeup of these towns, poverty levels are up, and it's a lot of like minority communities.* [...] *I think like, a lot of times (these towns) get talked about, like there's nothing out there, but there are people out there. So that's the disconnect right now that's happening* [...] *even the way* (my company) *talks about the people from these towns isn't very dignifying because a lot of these people end up working as contractors* [for my company]*, and they don't have a formal education. But* [...] *just because we have an engineering degree, and we just get to fly out and sit in the air-conditioned trailer, while these people are going to be outside in the 114 degree heat for however many hours.[*(So I am interested in] *how do we do better for them? It's almost a human rights, or labor rights issue.*

In this passage, the student identifies two oppressive systems within the engineering firm where she interns. Firstly, she highlights the absence of adequate discussion in their sustainability report about the corporation's impact on the marginalized community from which they source raw materials. This could be seen as the oppressive norm of engineering firms prioritizing various indicators of success, such as money, innovation, and environmental impact, over the wellness of marginalized communities. To address this, this student is actively involved in a project on how indicators of the social impact of this company's operations could be added to the sustainability report. Secondly, the student also discusses a norm of dehumanizing or prejudiced discourse

about the members of these communities. While she expresses motivation to address this issue, she acknowledges uncertainty about changing her coworkers' prejudiced perspectives. Despite her confusion in addressing this oppressive norm, she aligns with the principles of transformational resistance because she has identified this norm of prejudiced speech and is motivated to disrupt it.

Other students, like the following, reflected on oppressive systems that originated outside of an engineering organization. In particular, this student reflects on a country's policy towards a marginalized community and her goals to move against this goal through an engineering project.

So we have been working with this [Alaskan indigenous] *community to design this solar system, and there are ties to decolonization. So the United States abolished Aboriginal land titles in Alaska in 1971. Before that, this community had a subsistence economy and was sustaining themselves. They have since had a lot of people move away just because they needed to get higher-paying jobs, especially to pay for their energy bills because they are so high. And if there was a solar array that they could maintain themselves, it would help supplement their energy. This solar array is something that their community will own and another way that they will be able to support themselves without having to rely on subsidies from a government that stole from them in the first place. [...] I think that the fact that it is unaffordable for people to live safely and warmly in an area that they are indigenous to is just like a really glaring red flag for how US policy treats indigenous people throughout the country. [...] So, I mean, that's the scope of what we would be able to address in our project. And when we give presentations (on our project), we point out, like, isn't it crazy that the government took all these land titles and then established corporations to force work on these tribes? Doesn't that make no sense?*

This student recognized the United 1971 Alaska Native Claims Settlement Act as an oppressive system that took land from indigenous populations, subjecting them to an oppressive relationship with the corporations to which their land was transferred [31]. Motivated to diminish the influence of these corporations on the indigenous communities' way of life, the student chose to work on solar projects in this community as a method for energy independence, so they do not have to continue paying this corporation for energy. This passage emphasizes how the Transformational Resistance principles have the potential to guide not only individual actions to influence engineering conferences, coworkers, and corporations but also as a framework that may act as scaffolding for HE projects to combat oppressive systems that originated outside of the engineering organization itself.

This study found students reporting instances of transformational resistance when they were both motivated by social justice and critiquing social oppression. Specifically, students were critical of norms, policies, and cultures that perpetuate discrimination, marginalization, and inequality and were motivated to challenge and counteract these systems. Students were motivated to

improve insufficient social justice goals in HE, advocating for increased representation in HE spaces, encouraging engineering companies to consider the communities they impact, and weakening oppressive policies within the United States.

Limitations and Future Directions

As the Transformational Resistance (TR) framework originated from Critical Race Theory principles, it is crucial to center the impact of race on students' actions and aspirations. Critical Race Theory acknowledges that racism is permanent and deeply ingrained in U.S. society and should be centrally examined [32], [33]. White folks became a high tier of social dominance when Gomes de Zurara invented "whiteness" to justify treating individuals who carry an arbitrary set of constructs, such as last name, skin color, religion, lineage, and accent, with entitlements, with the intent of economically benefiting colonial European powers [34]. Whiteness greatly affects one's lived experience and thus is likely to have a great impact on a student's experience growing as a social activist [35].

The demographic landscape of HE programs underscores the need to explore how race and nationality can influence the aspirations and actions of students who are critical of social oppression and motivated for social justice. Specifically, HE programs face challenges in increasing the representation of students from low and middle-income countries, and engineering spaces can continue to be hostile environments, where students of color represent 21% and 14% of engineering and science masters and doctorates, respectively [36]. Future studies will delve into how inherent privileges and common practices of socially dominant individuals may complicate and pose challenges to a student's capacity for social justice activism.

Finally, given the educational aims of HE programs and the lack of studies on HE students' growth as social justice engineers, future work will characterize how learning experiences in HE programs influence graduate students to advocate for social justice in their daily actions and career aspirations using the transformational framework. Specifically, we wish to characterize the barriers that hinder the ability to achieve transformational resistance, either from a lack of social justice motivation or a lack of critique of social oppression. Further, by studying additional students across the programs, we wish to simultaneously identify the enablers of transformational resistance, highlighting the learning experiences that propel both a motivation for social justice and a critique of social oppression.

Conclusion

In conclusion, our study has illuminated the potential for Humanitarian Engineering students to act as agents of change within the unjust and inequitable world around them. This preliminary study found students demonstrating a strong motivation for social justice, ranging from a sense of solidarity with marginalized populations to drawing inspiration from the resilience of these communities and feeling an obligation to advocate for social justice. Simultaneously, the study

unveiled students actively critiquing oppressive structures within HE and the broader engineering field, encompassing policies, norms, and cultures perpetuating discrimination and contributing to community marginalization. This critical examination included pay discrepancies and insufficient integration of community desires, as well as larger global systems of oppression, such as the intricate dynamics of colonialism and capitalism. Finally, the study identified students who were both critical of social oppression and motivated for social justice, showcasing their commitment to challenging and counteracting systemic issues in the HE field, advocating for increased representation, promoting community considerations in engineering practices, and contesting oppressive policies within the United States.

Previous studies have illustrated the value and potential of marginalized students being both motivated for social justice and critical of social oppression. This study, which focused on humanitarian students, found the potential for socially dominant students to display these same principles, dismantling systems of oppression they are privileged to ignore. Past research indicates that marginalized students, guided by the principles of Transformational Resistance, frequently exhibit distinctive and powerful characteristics. These include a robust sense of self, purposeful questioning, active advocacy for themselves and their communities, a heightened awareness of injustices, and/or a multicultural and intersectional understanding of the world [25], [26], [27]. Excitingly, this study suggests that socially dominant students may also exhibit the potential to embody the principles of transformational resistance. Therefore, there is an intriguing possibility that these principles can guide socially dominant students towards cultivating similar powerful characteristics, such as purposeful questioning and multicultural awareness. Further, this framework can aid students seeking to transform humanitarian engineering for just community outcomes.

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