Humanitarian Engineering Education: Exploring the Evolution of Student Self-Efficacy, Career Expectations, and Capacity to Transform Engineering Structures During their Graduate Education

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Abstract

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Engineering for Social Justice: A Longitudinal Study of Student Development in Humanitarian Engineering Graduate Programs

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Infrastructure and public service disparities persist globally, with many communities lacking reliable access to essential services like water, sanitation, and energy. Humanitarian engineering (HE) programs aim to address these disparities by training engineers to implement sustainable and equitable solutions. However, as the field undergoes a fundamental reckoning with its colonial legacy and impact, there is limited understanding of how these programs develop students' capacity to create meaningful social change.

Through four interconnected studies, this dissertation progressively examines key aspects of students' development in humanitarian engineering education. The first study employs Social Cognitive Career Theory to investigate how students question and reassess their equity-focused career aspirations during graduate school. This foundational analysis reveals patterns in how learning experiences shape students' career confidence and outcome expectations, providing crucial insights for supporting professional development in the field. Building on these findings about students' growing awareness of systemic barriers, the second study utilizes the Transformational Resistance Framework to analyze educational practices that inhibit or facilitate students' capacity to identify and resist oppressive structures in HE. This examination illuminates how learning environments can nurture or stifle students' development into agents of social change.

Given the importance of self-efficacy in sustaining social justice work, the third study then applies the Social Justice Self-Efficacy construct to track how students develop confidence across multiple domains of activism - personal, interpersonal, community, and institutional. This longitudinal analysis reveals distinct phases in students' development of social justice capabilities, informing how programs can sequence and structure learning experiences. Throughout this investigation, the perspectives of students from low and middle-income countries emerged as crucial for enriching social justice development in HE programs. This led to the fourth study's use of Yosso's Community Cultural Wealth framework to examine how to create supportive learning environments for these students.

The findings advance theoretical understanding of how career expectations, resistance behaviors, and social justice capabilities develop in HE education while providing practical recommendations for nurturing students' capacity to create change. These insights can help programs prepare a diverse generation of humanitarian engineers equipped to address global infrastructure disparities through sustainable and equitable approaches.

Acknowledgments

For a while, when thinking about the acknowledgments section of my dissertation, I go back to what a student in my study shared when discussing how to avoid the savior mindset in humanitarian engineering:

One thing that every Hispanic mom has heard and tells their kids is 'it takes a village to raise a child.' [...] *You have so many different people that influence your life, whether it's aunts and uncles who help you grow up, or your childhood best friend who moved away.* [...] *They taught you things regardless of whether you realize it or not.* [...] *Tying that to humanitarian engineering helps you realize that you, at best, are a cog.* [...] *You go in a community as a zero, getting context, building relationships, and then you're able to say, "Okay, this is something I think we can build as a community."*

I have kept this wisdom with me for the past four years since I interviewed him, and it is especially relevant as I acknowledge the village that helped me reach this dissertation milestone.

It took the original village my family created for me, including the support, kindness, and belief in myself they instilled throughout my childhood and their willingness to quiz me on my times tables and to edit rambling, metaphor-filled writing. They continue to create refuge during vacation breaks, stressful pre-"something" weeks whether pre-lims, comps or my defense, where they stocked the fridge and created peaceful respite, and phone calls where I continually realize how supported, believed in, and cared for I am.

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I have a village of mentors, people—and let's be honest, often women—who let me share my confused, poorly worded ideas and gave me back beautiful, articulate understandings of the world and directions I could go in. They edited pages and pages of work, often showed me they were thinking of my career goals, networked on my behalf, and gave me spaces to mess up, reflect, and continue dreaming for the future. Teachers who thought critically and deeply about nurturing their students' critical perspectives, talents, and drive to add to the communities they cared for. Further, I had peers who shared my work, concerns, woes, and goals in this PhD journey and celebrated with me both the big milestones and the simple but important-to-celebrate accomplishments of finishing a day of work—when that work is something you simultaneously feel passionate, nervous, bored, excited, fearful, confident, and insecure about.

My journey was supported by a village of scholars and community activists whose victories, setbacks, and bravery instill pride and hope in me about the humans who have built and supported communities throughout this country and continent, both historically and today. This includes the community members throughout this nation's history who were brave enough to share their lived experiences of hardship, exploitation, love, and mistakes in hopes of making our national understanding of itself more expanded and factual—those who shared via books, articles, poems, podcasts, art, daily kindness, and conversations with their loved ones. I'm also grateful to the community members who took space to listen, especially when it made them uncomfortable and anxious; the community members who stepped down from platforms of power for others; and the communities who convinced and advocated for individuals to step down from platforms of power for others. I have been upheld and supported by a village of scholars dedicated to being critical and honest about this country, while simultaneously pouring energy and love into this country with the goal that we learn to better serve all living beings, the spirit they carry, and the built and natural environments we rest in.

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As the student in my study so nicely articulated, I can only hope at best to be a helpful cog in the many communities I am a part of. With this acknowledgment, I work to support, remember gratitude for, and remember my love for these villages of people and communities throughout my life and career. Further, I look forward to all the lessons, relationships, mistakes, tools, and spaces we build together.

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Chapter 1. Introduction

Research Context and Motivation

Graduate educational programs aimed at training engineers to address national and global infrastructure and public service disparities, often referred to as Humanitarian Engineering (HE) programs, represent an emerging discipline in engineering education. These programs advertise explicit commitments to diversity, sustainability, and partnerships with marginalized communities. For instance, these programs often prioritize the needs and desires of users in engineering design and focus on modern-day engineering initiatives such as the sustainable development goals (Boy, 2021; MacDonald et al., 2022). However, HE programs are relatively new and understudied. Since the Colorado School of Mines established the first HE minor in 2002, the field has grown substantially, with 67 HE programs and initiatives operating across the United States in 2020 (CSM, 2020; EWB, 2021; Smith et al., 2020).

Supporting HE students' career pathways is crucial as these students demonstrate unique and valuable traits that the engineering field needs to retain. Studies reveal that HE students are more motivated to contribute to social good and are more willing to sacrifice higher salaries for socially impactful careers than their peers in other engineering disciplines (Budny & Gradoville, 2011; Swan et al., 2014). Beyond motivation, engineers who receive training on their responsibility to public welfare—a standard component of HE education—demonstrate a more significant understanding of their role in protecting public health and safety while better recognizing their work's social and ethical dimensions (Cech, 2014). Importantly, participation in HE activities does not compromise technical abilities; engineers involved with the HE club Engineers Without Borders (EWB) show equal technical self-efficacy to their engineering peers and enhanced

professional self-efficacy in skills like multidisciplinary teamwork, communication, and understanding of professional and ethical responsibilities (Litchfield et al., 2016).

Retaining and supporting these students is also important as HE programs can attract students of diverse backgrounds to engineering (Swan et al., 2014). Female students and students of color disproportionately cite "wanting to help people" as a significant motivator for pursuing engineering (Barrington & Duffy, 2007; Brubaker et al., 2017; Romkey, 2007). Further engineering courses with humanitarian design projects demonstrate stronger retention rates of students from underrepresented groups (Adams & Burgoyne, 2017). Recognizing these patterns, universities are creating HE educational programs in part to increase the recruitment and retention of underrepresented students (Delplanque & Gosink, 2004; Swan et al., 2014).

However, few studies investigate the educational experiences of these diverse and passionate cohorts of students, especially on how learning experiences during HE programs influence students' career goals and capabilities. Specifically, the field needs more data that explores the influences between HE students' aspirational commitments to socially-minded engineering and their growth in their confidence to manifest tangible, equity-oriented change in infrastructure and public service disparities.

This lack of research is particularly concerning given that studies have shown HE educational experiences can sometimes lead to students questioning their career goals and capacity to do social good. Studies have revealed that HE students in various HE educational experiences face multiple challenges: perceiving limited avenues within engineering to serve underserved communities, leaving engineering programs due to perceived lack of social responsibility in the field, feeling frustrated when confronting complex ethical problems, and struggling to find paths for their

socially-minded aspirations in the engineering industry (Litchfield & Javernick-Will, 2017; Niles et al., 2018; Rulifson & Bielefeldt, 2017; Smith, 2019).

Moreover, students are likely to further question their career goals and capacity for social impact as the HE field undergoes a fundamental reckoning. This reckoning, as evidenced in publications like "Foreign Aid is Having a Reckoning" (New York Times, 2021) and "Black Lives Matter, is also a reckoning for foreign aid and international NGOs" (Ali, 2020), is challenging the field's best practices and ability to address social and environmental equity. At the heart of this reassessment is HE's deep colonial history, from 18th and 19th-century imperialism to present-day practices where marginalized communities have minimal sovereignty in their development (Lucena et al., 2010). Further, in the US, engineering firms have implemented infrastructure—from wastewater treatment centers to transportation systems—in ways that perpetuate institutional and environmental racism through their placement and quality (Winner, 1980; Yates & Murphy, 2019). This critical examination extends to HE educational programs, where researchers warn that even well-intentioned learning experiences like fieldwork can devolve into neo-colonial voluntourism that risks harming partner communities (Birzer & Hamilton, 2019). In response, the field is actively decolonizing by reimagining aspects of HE careers—from required skills and daily tasks to salary structures and impact metrics—while questioning who should lead these efforts and how students should be educated (Burleson et al., 2023b; Peace Direct et al., 2021). In line with these decolonizing efforts, HE programs are transforming their pedagogical approaches.

This dissertation aims to support the education and career pathways of socially-minded and diverse HE engineering students through longitudinal analysis of their development into agents of social change. Using robust, detail-rich data collected from students across multiple HE programs, this

dissertation examines how students' career aspirations and capacity to address infastructure and technology disparities evolve during their education.

To better understand how to support HE students, Chapter 2 investigates how HE graduate students' question their career aspirations during their graduate education, revealing two key challenges: students question both the field's capacity for meaningful social impact and their own ability to create change. As students learn about the complex historical, political, and systemic barriers to improving infrastructure access, they grow concerned both about their field's ability to transform its colonial practices and policies, and their own capacity to advance equity goals effectively. These findings, combined with HE's ongoing reckoning with colonial legacies, shaped the subsequent research focus on preparing students to identify and address systemic inequalities. First Chapter 3 examines students' development of resistance behavior—their ability to identify oppressive structures while maintaining motivation to change them. Then, Chapter 4 investigates students' growing self-efficacy in social justice activism, recognizing how confidence shapes career development and sustained engagement in social change. Throughout this investigation, the perspectives of students from low and middle-income countries (LMICs) emerged as crucial for enriching social justice development in HE programs. This led to Chapter 5's focus on examining how to create supportive learning environments for LMIC students, recognizing their vital role in transforming the field.

Theoretical Positioning: Engineering, Critical Race Theory, and Decoloniality

This dissertation operates at the intersection of humanitarian engineering education and social justice, necessitating critical examination of engineering as a discipline, not just its humanitarian applications. Rather than accepting engineering as a neutral, apolitical field, this study draws on

Critical Race Theory (CRT) as a framework that illuminates how engineering has been implicated in colonial projects, racial hierarchies, and systemic inequities.

Critical Race Theory offers valuable analytical tools for examining these dynamics within humanitarian engineering specifically. CRT's focus on experiential knowledge, commitment to social justice, critique of dominant ideologies, and in-depth understanding of US education and institutional systems (Solórzano & Yosso, 2002) provides a framework to analyze how humanitarian engineering programs can either challenge or reinforce existing power structures. By employing CRT, I analyze how engineering education can either perpetuate or disrupt colonial projects, racial hierarchies, and systemic inequities through the ways knowledge is produced, whose perspectives are valued, and how future engineers are prepared to engage with marginalized communities. This Critical Race Theory lens in engineering education does not reject scientific inquiry but expands the epistemic landscape by recognizing multiple, interdisciplinary, and lived experience knowledge systems as legitimate sources of engineering insight (Hubain et al., 2016; T. Yosso, 2005).

It is important to acknowledge that this dissertation operates within certain constraints. I am not calling for the abolition of engineering or universities, but rather examining how transformational resistance can occur within these institutions (Solórzano & Bernal, 2001). This approach recognizes the value of what Tuck and Yang (2012) describe as "keeping the lights on"—the incremental, but materially significant changes that can improve lives while broader structural change unfolds. By focusing on "micro-acts" of resistance within humanitarian engineering education, this research illuminates how students develop capacity to create meaningful change even while operating within systems shaped by colonial legacies.

Importantly, I recognize the caution raised by Tuck and Yang (2012) that "decolonization is not a metaphor." True decolonization involves land repatriation, Indigenous sovereignty, and the dismantling of settler colonial structures—goals that extend beyond the scope of reforming engineering education. However, this research contributes to a broader decolonial project by examining how humanitarian engineering education can incorporate more diverse knowledge systems, challenge dominant narratives about development, and prepare students to recognize their positionality within global power structures. While these educational interventions alone cannot accomplish decolonization, they represent necessary steps toward more just engineering practices.

In sum, by applying CRT to analyze students' educational experiences, this research contributes to our understanding of how engineering education can be reimagined to better serve marginalized communities and prepare students to work toward more equitable infrastructure and technology development.

Dissertation Structure and Format

This introduction serves to the overall dissertation, which is based on a journal-article format. As such, it introduces the overall structure, in addition to points of departure by chapter and research needs and questions. Chapter 6, the concluding chapter, summarizes the other chapters and outlines the individual and collective contributions from this dissertation.

The following section outlines four chapters of research that were motivated by supporting HE graduate education: investigating how students question and reassess their HE career expectations during their graduate education and which learning experiences prompt these reflections (Chapter 2); examining which HE educational practices either inhibit or facilitate students' capacity to identify and resist systemic inequalities in infrastructure development (Chapter 3); analyzing how

students' social justice self-efficacy evolves during their first year of graduate school (Chapter 4); and investigating how HE programs can create supportive rather than burdensome environments for students with ties to low and middle-income countries (Chapter 5).

Research Gaps and Points of Departure

Chapter Two: Career Development in Humanitarian Engineering

To better understand how to support HE students' career pathways, Chapter 2 works to develop a comprehensive understanding of how HE students question their socially-minded career aspirations and how learning experiences influence this questioning. While previous scholarship has established that HE educational experiences can prompt students to question their career expectations, a greater understanding of the comprehensive patterns in how students reevaluate their professional aspirations and which learning experiences trigger these reflections is needed. For instance, one university found that their HE undergraduate students perceived limited avenues within engineering to apply their skills toward infrastructure service provision in underserved communities (Smith, 2019). Another study found students can become frustrated and disengaged when confronting complex ethical and ambiguous dilemmas in HE courses (Niles et al., 2018). However, studies have not examined how graduate students across different HE programs reevaluate their career goals, nor have they systematically analyzed which learning experiences prompt these career reassessments.

While some scholarship exists on common learning experiences in HE programs, research is limited on how these experiences across different programs influence students' career goal reassessments. For instance, scholarship shows HE education typically combines academic coursework and experiential learning (Smith et al., 2020). Typically, coursework emphasizes understanding global and societal contexts of engineering while developing professional

competencies like collaborating with diverse stakeholders (Bielefeldt & Canney, 2016; Budny & Gradoville, 2011; Litchfield et al., 2016). In contrast, experiential learning—including internships, research, project-based work, and service-learning—prepares students for the HE field by enhancing teamwork abilities and fostering self-awareness, empathy, and cultural sensitivity (Birzer & Hamilton, 2019; Passino, 2009). However, the connections between these experiences and students' career reassessments remain understudied.

To help educational institutions better support HE graduate students' professional development and address critical gaps in understanding career trajectories, Chapter 2 examines how students reevaluate their career expectations during their education and identifies influential learning experiences. As such, this chapter addresses two research questions:

RQ1) How are graduate students questioning their HE career expectations throughout HE graduate programs?

RQ2) How are HE academic and experiential learning experiences prompting students to question these career expectations?"

Chapter Three: Systemic Inequality and Transformational Resistance

As the HE field becomes more concerned with systemic inequality—the interconnected structures of policies, assumptions, biases, traditions, norms, and explanations that perpetuate inequality (Sensoy & DiAngelo, 2017)—Chapter 3 investigates how to educate HE students to identify and maintain motivation to disrupt systemic inequity. This investigation responds to the field's ongoing reckoning with colonial legacies and power structures. The study aligns with decolonial and anti-racist movements in HE that emphasize preparing engineers to identify and actively resist oppressive structures both within the field and in broader development systems.

The need to address systemic inequities is well-documented on two fronts. First, within HE itself:

To help educational institutions better prepare engineers to address systemic inequality, Chapter 3 investigates how HE programs normalize compliance with or foster resistance to systemic oppression. The chapter examines this fundamental question:

RQ: Which HE educational practices inhibit or facilitate students' ability to identify, resist, and transform systemic oppression?

Chapter Four: Social Justice Self-Efficacy Development

As the field needs HE practitioners who can not only identify systemic inequalities but also effectively advocate for transformative change in policies, practices, and power dynamics, Chapter 4 investigates HE students' longitudinal growth in social justice self-efficacy—students' perceived ability to advocate for equitable resource access while empowering marginalized communities (Chapman, 2013; M. J. Miller et al., 2009). This investigation responds to growing demands for HE practitioners confident in social justice activism. The field's mission centers on global equity, with humanitarian engineers working to address barriers to essential services like water, sanitation, and energy (Thomas, 2020a). Moreover, anti-racism and decolonial movements have heightened expectations for practitioners to engage in workplace justice activism, from challenging discriminatory practices to reforming organizational policies (New York Times, 2021; Peace Direct et al., 2021). Recognizing these evolving demands, stakeholders identified fostering inclusive and diverse engineering teams as a key learning objective in HE education (MacDonald et al., 2022).

This study builds on literature showing varied impacts of HE education on students' social justice self-efficacy. Some experiences enhance efficacy: participation in Engineers Without Borders and HE clubs strengthen self-efficacy in professional skills and ethical responsibility awareness

(Litchfield et al., 2016) while training on public welfare responsibilities improves understanding of engineering's social dimensions (Cech, 2014). However, challenges exist—EWB-engaged students have reported struggling to find avenues for their social aspirations in engineering (Litchfield & Javernick-Will, 2017), indicating reduced confidence in achieving meaningful activism at the community level.

Chapter 4 conducts a longitudinal investigation of students' evolving confidence for social justice activism during their first year to better understand and support social justice self-efficacy development in HE graduate students. The chapter examines:

RQ: How does Social Justice Self-Efficacy change over time for students in humanitarian engineering graduate programs?

Chapter Five: Social Justice Self-Efficacy Development

As students with familial ties to LMICs become increasingly important to improving technological infrastructure disparities in the HE field, Chapter 5 investigates these students' educational experiences and how to best support them. This research responds to increasing calls for LMIC student enrollment and retention (Burleson et al., 2023b), as their perspectives are vital for transforming the field. Their involvement challenges traditional Eurocentric development paradigms (Peace Direct et al., 2021) while bringing crucial Indigenous knowledge, including deep familiarity with local communication practices and contextually developed solutions to environmental, social, and technical challenges (Roborgh et al., 2024; Senanayake, 2006).

This study builds on literature examining how marginalized students often face increased burdens when diversifying educational spaces. W.E.B. Du Bois (1935) provided an early critique of integration in US schools, arguing it harms students' of color's academic achievement by placing

them in hostile, unsupportive academic environments. This concern remains relevant today, as universities may prioritize recruitment over creating truly inclusive learning environments, often creating hostile spaces where marginalized individuals are expected to shoulder the responsibility for institutional change (Love, 2023). Furthermore, marginalized students may be tokenized or expected to serve as representatives of their communities in discussions about race, colonization, or social justice—often serving the emotional needs of White individuals rather than benefiting marginalized communities (hooks, 1994; Hubain et al., 2016).

Scholars have identified potential solutions through institutional practices and educational procedures. Research recommends designing campus services like academic advising, tutoring, and career guidance to address the intersectional needs of students from diverse backgrounds, acknowledging their unique experiences of historical and contemporary exclusion (Hailu et al., 2024). Additionally, Ladson-Billings (1995) introduced culturally relevant pedagogy to center the experiences and cultures of traditionally excluded students, emphasizing the importance of maintaining positive cultural and ethnic identities. While other disciplines have extensively explored how to mitigate the burdens of diversifying educational spaces, the HE field needs more scholarship to examine these challenges.

To help educational institutions better support students with ties to low and middle-income countries and develop more inclusive HE education, Chapter 5 investigates how to create supportive learning environments where LMIC-tied students can share their unique social and cultural capital. The chapter examines:

RQ: What institutional practices create supportive learning environments for LMIC-tied students?"

Research Methods

Overarching Research Design

This study employed longitudinal interviews to collect data from 46 students across seven HE graduate programs, including six to ten students per program. The selected programs offer either HE graduate certificates or degrees, each sharing goals similar to the Mortenson Center in Global Engineering and Resilience: 'promoting integrated and participatory solutions to humanitarian development by educating globally responsible engineering students and professionals to address the problems faced by developing communities worldwide' (MCGER, 2021). All participating programs had attended a 2021 NSF-funded workshop, 'Defining the emerging pedagogy in the field of Global Engineering,' where they aligned on common learning objectives and approaches (MacDonald et al., 2022). Student recruitment followed IRB-approved processes (IRB 21-0207), with program directors and professors distributing email advertisements to their respective HE cohorts.

The participant pool represented diverse backgrounds and experiences: 27 students were from dominant communities in engineering (white students from high-income countries), while 19 were from marginalized communities (students of color and students from low and middle-income countries). Participants varied in racial and ethnic identities, ages, and nationalities and were at different stages in their graduate education. During the interview, students self-identified their racial status or familial connection to low and middle-income countries.

Table 1-1 Numbers of Students Enrolled from Each HE program

School	Enrolled	Interview 1	Interview 2	Interview 3	Interview 4
University A	5	5	4	5	5
University B	5	5	3	2	3
University C	8	8	8	5	7

University D	11	11	10	10	10
University E	6	6	6	5	6
University F	6	6	6	6	6
University G	5	5	3	3	4
Total Students	46	46	40	36	41

Students participated in longitudinal interviews spanning two years, with interviews conducted each semester and summer beginning in Fall 2021. Using an ethnographic, semi-structured approach (Spradley, 1979), these interviews captured students' evolving career aspirations, activism goals, experiences, and reflections. Interview protocols included questions relevant to all four dissertation chapters. All interviews were transcribed using Trint software (Version 1.0.68, 2023) and imported into NVivo qualitative analysis software (Version 14, 2022).

Each chapter employed methodological approaches tailored to its research questions, varying in participant subsets, theoretical frameworks, interview questions, and analysis methods. While data analysis techniques varied across chapters, all chapters included qualitative analysis with deductive and inductive coding, balancing theory-driven analysis with emergent findings. The following sections detail these methodological choices for each chapter, including the specific theoretical frameworks, participant subsets, and coding schemes employed.

Chapter-Specific Methods and Frameworks

Chapter Two: Social Cognitive Career Theory

Social Cognitive Career Theory (SCCT) was employed to examine how graduate students question their HE career expectations throughout HE graduate programs. SCCT provides a theoretical foundation for understanding how learning experiences shape students' career expectations and

subsequent career choices (Lent et al., 1994; Schaub, 2004). The framework has proven particularly effective in studying engineering students' career development (Brubaker et al., 2017; Chubin et al., 2008; Lent et al., 2007). Within SCCT, career expectations encompass two key elements: outcome expectations (anticipated career benefits like salary or job satisfaction) and self-efficacy (beliefs about one's ability to succeed in career-related tasks). The framework suggests that students develop an interest in and choose careers where they believe they can achieve (high self-efficacy) and expect satisfying outcomes.

Further, to examine how HE academic and experiential learning experiences prompt students to question these career expectations, SCCT illustrates that self-efficacy and outcome expectations are highly influenced by four distinct types of learning experiences: mastery experiences (direct successes or failures in relevant tasks that provide evidence of capability to succeed in career-related tasks), vicarious experiences (observations of others' successes or failures in similar career roles), verbal persuasion (encouragement or discouragement from others about one's abilities to succeed in relevant tasks), and emotional responses (feelings of anxiety or confidence when attempting career-related tasks) (Bandura, 1997). Thus, tracking changes in outcome expectations and self-efficacy and identifying which learning experiences trigger these changes can illuminate how and why students reassess their career goals during their HE graduate education.

To examine these research questions, this chapter used the complete dataset of 164 interviews conducted with 46 students. Interview guides were designed each semester to align with students' progression through their programs, while maintaining consistent core elements. Initial interviews focused on understanding students' career aspirations and their development, while subsequent interviews tracked how these goals evolved over time through open-ended questions like "How have your career goals changed?" Following SCCT's framework, the interviews explored the four

learning experience types: They investigated mastery experiences through questions about HE experiential successes and challenges, examined vicarious learning through discussions of role models, probed for verbal persuasion from various sources including peers and mentors, and explored emotional responses during key experiences. This comprehensive approach enabled tracking of both career expectation changes and the learning experiences that influenced these shifts.

For research question 1, the analysis first deductively coded instances where students questioned their HE career expectations, defined as moments when students contemplated whether an HE career would help them achieve their goals, their ability to complete necessary tasks, or their ability to secure an HE position. These instances were then inductively coded into emerging themes that characterized different types of career questioning. For research question 2, the study examined how learning experiences influenced these career reassessments through two levels of deductive coding: first categorizing experiences as either academic learning (coursework, seminars) or HE experientials (project-based learning, internships, research), then sub-coding these according to SCCT's four learning experience types (mastery, verbal persuasion, vicarious, and emotional distress). Through this analysis of both career questioning and learning experiences, the study revealed patterns in how students' career expectations evolved throughout their HE education.

Chapter Three: Transformational Resistance

In asking which HE practices either inhibit or facilitate students in identifying, resisting, and transforming systemic oppression, this study utilized the Transformational Resistance Framework (TRF). Originally developed to understand how students of color identify, subvert, and transform inequitable educational structures that hinder their academic success (Solórzano & Bernal, 2001), TRF illuminates how students actively struggle against systemic inequality, such as racism, neo-

colonialism, and white supremacy (Beth Clarkson et al., 2022; Chen, 2020; Deeb-Sossa & Boulware, 2022). In the context of this study, the TRF helps examine how students identify, subvert, and transform archaic and neocolonial structures in the HE field through three forms of resistant behaviors: those driven by a critique of social oppression, those motivated by social justice, and transformational resistance which combines both. Social oppression refers to interconnected structures—policies, practices, traditions, norms, and narratives—that exploit, silence, and marginalize certain groups while benefiting dominant groups (Sensoy & DiAngelo, 2017). Meanwhile, social justice involves not just equitable access to resources, opportunities, and liberties for all, but specifically empowering marginalized groups (Chapman, 2013; Solórzano & Bernal, 2001). The integration of both critiquing oppression and pursuing justice—transformational resistance—represents the highest level of student agency and potential for social transformation, as it empowers individuals to both recognize oppressive structures and work to dismantle them.

To analyze the interviews, the study first deductively coded instances of the three resistance behaviors using the TRF framework: first, motivation for social justice, which included expressions of desire to create equitable access to resources and empower marginalized communities; second, critique of social oppression, which captured moments when students identified and questioned harmful policies, practices, or power dynamics that marginalize certain groups; and third, transformational resistance, which included instances where students combined both a critique of oppression and motivation for justice in their reflections and actions. The analysis then moved to inductive coding to identify what influenced students' resistance behaviors, noting recurring patterns related to their coursework experiences, interactions with faculty, exposure to media, and conversations with peers. Through multiple rounds of analysis and refinement, these

categories helped reveal specific ways that HE learning environments either support or hinder students' development into engineers who can recognize and address systemic inequalities.

Chapter Four: Social Justice Self-Efficacy

To understand how Social Justice Self-Efficacy (SJSE) changes over an HE graduate program for students, this study employed Miller's (2009) SJSE construct. SJSE refers to students' judgment of their own capacity to work toward equitable access to resources, opportunities, and liberties for all while empowering marginalized communities (Bandura, 1986; Chapman, 2013). Research has shown that increased SJSE correlates with college students' enhanced social justice interest and commitment (M. J. Miller et al., 2009) and increased commitment to advocacy for others in their careers (Van Voorhis & Hostetter, 2006). The construct examines students' confidence across four key domains: personal SJSE (ability to examine one's own worldview and biases), interpersonal SJSE (ability to challenge others' perspectives and prejudicial attitudes), community SJSE (ability to support efforts reducing inequitable access to resources in specific communities), and institutional SJSE (ability to influence change within systems by reforming norms and policies that perpetuate injustice). These domains synthesize various ecological social justice frameworks to provide a comprehensive assessment of students' development of social justice capabilities.

To allow for rich longitudinal analysis, this chapter focused on a subset of the study population: the 22 students who began their programs in Fall 2021 and completed all four interviews over their first three semesters. The interview guide probed for the four key dimensions of Social Justice Self-Efficacy (SJSE). To explore personal SJSE, the interviews investigated students' self-reflection and awareness through questions about how educational experiences, whether courses or project-based work, challenged or reinforced their worldviews. For interpersonal SJSE, questions explored students' willingness and ability to engage with others by inquiring about times

they encountered problematic views about development and how they responded. To understand community SJSE, the analysis assessed confidence in creating positive change in marginalized communities through HE projects. Finally, to assess institutional SJSE, students were asked about their views on needed systemic changes in development organizations and their perceived capacity to influence such transformations. This systematic approach enabled tracking how students' confidence evolved across all four SJSE dimensions throughout their graduate education.

To analyze the interview data, this study employed abductive analysis, adapting the SJSE theoretical framework to the HE context. The analysis began with the four domains of SJSE—personal, interpersonal, community, and institutional—and modified these to focus on how each form of activism related to improving access to essential services in marginalized communities. For example, Personal SJSE involved students' critical self-reflection and worldview evolution regarding the causes, consequences, and solutions to unequal access to essential services like water, sanitation, and energy. Within each domain, the analysis tracked both increases in self-efficacy, where students expressed growing confidence in their ability to create change, and decreases, where students expressed doubts or setbacks. The study then deductively coded for when and how these SJSE changes occurred throughout students' graduate education. Experiences were categorized into three primary contexts: coursework (traditional classroom settings), experiential learning (project-based work and thesis development), and external experiences (fieldwork, internships, and off-campus projects). This analytical process enabled an examination of how different educational contexts influenced students' development of social justice capabilities across multiple domains of activism.

Chapter Five: Community Cultural Wealth

To investigate what institutional practices create supportive learning environments for LMIC-tied students, this study employed Yosso's (2005) Community Cultural Wealth (CCW) framework. CCW provides a theoretical foundation for understanding how marginalized students bring valuable assets to educational spaces through six distinct forms of capital: aspirational (maintaining hopes despite barriers), linguistic (multilingual communication skills), social (supportive networks), familial (cultural knowledge and community obligation), resistance (capabilities developed through challenging subordination), and navigational (strategies for institutions not designed for them).

Chapter 5 focused on 19 students who had at least one parent from a Low or Middle-income Country (LMIC), with representation ranging from one to six students per program. The interview protocol explored how students' Community Cultural Wealth manifested and was received in their HE education through questions about their semester experiences, coursework, and experiential learning. Students were invited to share instances where they felt supported within their education or extracurricular activities and when they encountered less supportive, burdensome, or hostile experiences, focusing on experiences they felt were influenced by their identities. To gain more pointed insights, the protocol included questions specific to the CCW framework, exploring how their home life and various forms of capital resonated with them and influenced their career aspirations and graduate school experience.

To analyze the interview data, the analysis first deductively coded for instances where students shared their Community Cultural Wealth in their HE education, including moments where they contributed insights to peers, applied their capital to improve HE projects or discussed their unique perspectives when prompted by faculty. These instances were then sub-coded according to the six

forms of CCW. A second round of deductive coding, using literature on burdens and supportive learning environments for marginalized students, identified when students perceived these sharing experiences were "burdensome" (creating undue responsibilities or strain) or "supportive" (contributing to equitable learning and development). Through this systematic analysis, the study identified specific institutional practices and environments that either supported or burdened LMIC-tied students in sharing their valuable cultural wealth within HE programs.

Overview of Chapters

Table 1 synthesizes the key components of this dissertation's four main studies, outlining the research gaps addressed, research questions investigated, and methodological approaches employed in each chapter.

Table 1-2 Summary of gaps, questions, methods, and submission status for each chapter

Gaps/Needs	Research Question(s)	Methodology
Chapter 2: Supporting HE students' career pathways is crucial as these students demonstrate unique motivation for social impact and enhanced understanding of engineering's societal responsibilities. However, few studies have examined how these students question and reassess their career goals during graduate education, or which learning experiences prompt this reassessment	RQ1) How are graduate students questioning their humanitarian engineering career expectations throughout HE graduate programs? RQ2) How are HE academic and experiential learning experiences prompting students to question these career expectations?	Deductive Codes: 1) Changes in career expectations (self-efficacy and outcome expectations) based on Social Cognitive Career Theory 2) Influential learning experience categories (Mastery, Vicarious, Verbal Persuasion, Emotional) based on Social Cognitive Career Theory 3) Main Types of Learning experiences in HE, Experientials and Coursework Learning Inductive Codes: Themes in career questioning
Chapter 3: As HE confronts its colonial legacy, preparing students to identify and challenge systemic inequalities is essential for transforming the field's practices and impact. While some case studies show promise in fostering resistance to oppressive structures, larger-scale research across multiple institutions is needed to understand which educational practices effectively develop these capabilities.	*W*hich humanitarian engineering practices either inhibit or facilitate students' critique of social oppression and motivation for social justice?	Deductive Codes: Quadrants of the Transformational Resistance Framework (Reactionary Behavior, Conformist Resistance, Self-Defeating Resistance, Transformational Resistance) Inductive Codes: Learning experiences that push and pull students between different forms of resistance
Chapter 4: The field increasingly demands practitioners who can confidently engage in social justice activism to reform both organizational practices and development approaches. Yet limited research has investigated how students develop this confidence throughout their HE graduate education or which learning experiences foster it.	How does Social Justice Self-Efficacy change over time for students in humanitarian engineering programs?	Deductive Codes: 1) Categories of Social Justice Self-Efficacy (Personal Activism, Interpersonal Activism, Community Activism, and Institutional Activism) 2) Time based codes of HE learning experiences, Coursework, Experiential learning, Fieldwork, Semester 1, 2, and 3

Chapter 5: Students with familal ties to low and middle-income (LMIC) countries bring crucial perspectives for decolonizing HE practices and improving infrastructure development in marginalized communities. Despite growing recognition of their importance and calls for increased enrollment, minimal research exists on how to create supportive rather than burdensome learning environments for these students.	What institutional practices create supportive learning environments for LMIC-tied students?	Deductive Codes: Forms of Community Cultural Wealth (Familial Capital, Social Capital, Resistance Capital, Navigational Capital, Linguistic Capital, Aspirational Capital) Students feeling burdened or supporting during the sharing and utilization of this capital

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Chapter 2. Exploring Concerns in Equity-Focused Career Goals Among Humanitarian Engineering Students: Investigating the Influence of Graduate Education

Abstract

Humanitarian engineering (HE) graduate programs aim to improve environmental and social equity by training engineers to identify and rectify disparities in infrastructure services. While these programs help increase the engineering field's focus on equity, students involved in HE activities have reported questioning their ability to have a social impact through an engineering career. Social Cognitive Career Theory (SCCT) posits that career goals are created by students' career expectations, including the expected benefits students associate with a career and their confidence to perform specific tasks needed for a career. Further, SCCT posits that four types of learning experiences significantly influence students' career expectations: experiencing personal successes (mastery), receiving verbal encouragement (verbal persuasion), having access to relevant models (vicarious), and encountering low levels of negative emotions (emotional distress). This research explores how students enrolled in HE graduate programs reassess or question their equity career goals and the learning experiences that prompt this reassessment. To do so, we conducted multiple semi-structured interviews with 46 students enrolled in seven graduate HE programs over two years. These interviews centered around students' career aspirations, including when students questioned their career expectations and the learning experiences that prompted this reassessment. As a result, this work characterizes students' concerns around having a social and environmental impact through engineering and associates this questioning with learning experiences common to HE graduate education. By highlighting these concerns and associated learning experiences, we identify common struggles and supports students

need in HE programs and reflect on challenges to improving social and environmental equity through engineering.

Practical Applications

Humanitarian engineering prepares engineers to create infrastructure and technology to improve global social and environmental inequalities. This study reveals important insights for universities, engineering organizations, and students interested in humanitarian engineering careers. The research found that graduate students often struggle with maintaining motivation and confidence in their career goals as they learn more about the field's challenges and limitations. Students particularly questioned whether engineering organizations could effectively prioritize social impact over traditional profit-focused goals, whether they could create meaningful change as outsiders in communities, and whether humanitarian engineering careers could provide satisfactory work-life balance and financial stability. To better support these students, engineering programs should balance teaching about past project failures with successful examples that students can learn from and build upon and provide more structured support for students as they navigate complex trade-offs in their projects between being sustainable, historically conscious, financially feasible, and socially acceptable. Finally, engineering organizations interested in attracting humanitarian engineering graduates should consider better demonstrating their commitment to social and environmental impact while providing clearer career pathways that allow for both meaningful impact and personal well-being. These findings can help strengthen humanitarian engineering education and ultimately improve how engineering addresses social and environmental challenges.

Introduction

Humanitarian engineering (HE) is an engineering discipline that guides students in addressing social and environmental equity issues. Specifically, HE programs train students to carry a "concern with the unequal and unjust distribution of access to basic services such as water, sanitation, and shelter, and place emphasis on identifying the drivers, determinants, and solutions toward increasing equitable access to reliable services" (Thomas 2020 p. 10). This training challenges the historical legacy of engineers who have implemented infrastructure systems (e.g., bridges, wastewater treatment) whose placement and quality perpetuate institutional and environmental racism (Jones and Armanios 2020; Winner 1980; Yates and Murphy 2019). Further it aligns with the Accreditation Board for Engineering and Technology Student Outcomes, which mandates that all engineering programs train students to apply engineering design with consideration of public health, safety, and welfare, as well as global cultural, social, environmental, and economic factors (ABET 2022).

However, despite HE graduate programs growing in popularity across the US, there remains a scarcity of research on the specific learning experiences that shape students' dedication to pursuing a HE career, (Smith et al. 2020), which is a career that broadly pursues addressing or mitigating social disparities through engineering. Further, existing studies reveal that HE-oriented students may experience discontentment and insecurity regarding their ability to pursue social equity-centered career goals as they gain more experience and training within the HE and broader engineering sectors (Litchfield and Javernick-Will 2017; Smith 2019). To better understand student questioning of career goals and the learning experiences prompting this questioning, this research investigated how HE graduate students reevaluate their equity-centered career goals and

the learning experiences that prompt such reevaluation through the course of their graduate program.

Background

Humanitarian Engineering Education

Humanitarian Engineering (HE) programs share a common overarching goal of training individuals to address or mitigate social and environmental inequity through engineering but vary in many ways. For instance, HE programs are labeled under various names, including humanitarian engineering, development engineering, peace engineering, and global engineering. Further, while some HE students are preparing for roles in aid organizations focused on low-income communities, others intend to instill social and environmental equity principles in corporate engineering firms (Smith et al. 2020).

While some differences between programs exist, commonalities include going beyond a concern for the environmental impact of engineering efforts to also center the well-being of society and marginalized populations (Smith et al. 2020). To do so, HE programs often have academic and experiential learning components (Smith et al. 2020). In academic learning or coursework, HE programs emphasize the need to deeply understand the global and societal context in which engineering operates and aim to instill professional competencies, such as effective collaboration with stakeholders representing diverse social, ethnic, and national backgrounds (Bielefeldt and Canney 2016; Budny and Gradoville 2011; Litchfield et al. 2016). Then, in experiential learning experiences (called experientials in this paper), students partake in internships, research, project-based learning, or service-learning. HE experientials are widely recognized as crucial for preparing students to enter the HE field, enhancing their teamwork skills, and fostering their development of self-awareness, empathy, and cultural sensitivity (Birzer and Hamilton 2019; Passino 2009).

Students actively engaged in HE academic and experiential learning exhibit distinct career goals and expectations, which can be associated with an increased desire to address social and environmental equity. Research indicates that these students often possess technical skills on par with their traditional engineering peers, but they hold a stronger belief in their professional skills (Litchfield et al. 2016). This heightened emphasis on professional skills aligns with HE students' increased motivation to contribute to social good and their eagerness to acquire practical competencies (Swan et al. 2014). Further, undergraduates involved in HE experientials have expressed a desire to transcend the traditional role of an engineer, criticizing the conventional engineering approach as being too "robotic" and less human-centered (Niles et al. 2018). For instance, some students involved in a HE student club, Engineers Without Borders (EWB), do not readily identify themselves solely as engineers due to their enjoyment of humanities courses and desire for social good (Litchfield and Javernick-Will 2015).

Unfortunately, some studies have indicated that HE students may be experiencing a growing uncertainty regarding their career expectations in improving social and environmental equity through engineering. Prior research has revealed that undergraduate students involved with EWB often grapple with disillusionment as they struggle to meet their socially oriented career aspirations in the engineering industry (Litchfield and Javernick-Will 2017). Another study found that HE students perceive limited avenues within engineering to apply their skills and knowledge toward infrastructure service provision in underserved communities (Smith 2019). Further, HE students have expressed that they just wanted to know "what to do" when encountering complex ethical and ambiguous questions and, when feeling frustrated that there was no clear answer, have expressed feeling disengaged from discussion topics around systematic oppression (Niles et al. 2018). Other scholarship has shown undergraduates leave their engineering programs due to a perceived lack of

social responsibility in engineering courses and the profession, believing they can better serve marginalized communities elsewhere (Rulifson and Bielefeldt 2017). While these findings indicate that HE students may carry concerns in their social and environmental equity career goals as they gain more engineering experience and HE education, there is a shortage of research on the connection between HE learning experiences and students' concern in addressing equity through engineering.

This knowledge gap is significant today, as the HE field is undergoing a reckoning, questioning the best practices and possibility of addressing social and environmental equity through engineering. Failure in HE initiatives is a growing topic of discussion, exemplified by initiatives like the EWB Harvard failure forums, established in 2018, to bring together students, professionals, and community members to candidly address shortcomings in international HE projects (Harvard EWB 2020). Furthermore, a surge in media is questioning HE initiatives' capacity to induce lasting change, as exemplified by Jason Hickel's book "The Divide", (Hickel 2018) . which challenges the conventional narrative on global inequality and development, contending that aid, including various forms of HE efforts, may not alleviate poverty but rather perpetuate inequality. Hickel emphasizes how aid often comes with conditions that favor affluent nations at the expense of poorer ones and can create dependency while undermining local economies (Hickel 2018). Indeed, HE has a colonial legacy, tracing back to 18th and 19th-century imperialism to today, where marginalized communities often possess limited autonomy over their development (Lucena et al. 2010). Opinion pieces like "Foreign Aid is Having a Reckoning" and "Black Lives Matter is Also a Reckoning for Foreign Aid and International NGOs" (Ali 2020; New York Times 2021), showcase how the HE field is confronting its colonial and racist structures. As the HE field has been facing critical questions about its ability to create meaningful

influence career expectations: vicarious experiences, verbal persuasion, mastery experiences, and emotional distress, illustrated in Figure 1.

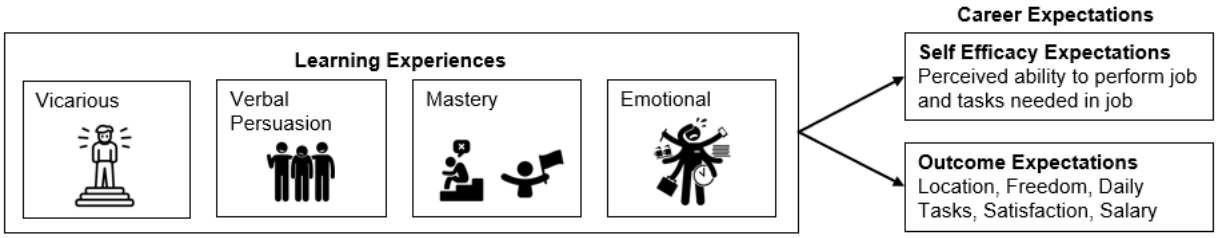

Figure 2-1 Learning Experiences Influence on Career Expectations, Adapted from Bandura (1997)

Vicarious experiences are examples and observations of other people's performances of tasks and careers. Positive observations of others' success foster student's belief in personal improvement through persistence and effort, and conversely, witnessing others fail despite earnest attempts negatively impacts self-efficacy. *Verbal persuasion* involves statements about students' capabilities from those around them, which influences their self-perception. Students are sensitive to discouragement and encouragement in their capabilities from professors, parents, bosses, friends, and social media. *Mastery experiences* are characterized by success or failure in specific situations and are extremely influential sources of self-efficacy as they provide evidence of whether a student has the capabilities necessary to succeed (Bandura 1997). Finally, *emotional* distress, or sensations of stress or anxiety when attempting a mastery experience, shapes self-efficacy beliefs. Specifically, students interpret negative feelings as signs of inadequacy, potentially leading to lower career expectations (Bandura 1997; Lent et al. 2017).

Importantly, SCCT asserts that the four types of learning experiences also play a pivotal role in shaping outcome expectations. In essence, when individuals encounter favorable levels of all four learning experience variables—such as experiencing personal successes, receiving verbal

encouragement, having access to relevant models, and encountering low levels of emotional distress—within a specific field of study and career, it fosters optimistic outcome expectations.

In sum, students' career goals and choices are profoundly influenced by their career expectations regarding a specific career field. Further, four types of learning experiences influence these expectations: mastery, vicarious, verbal persuasion, and emotional distress.

Research questions

Given the influence of career expectations on students' career goals and choices, it is essential to characterize how students question their career expectations to improve environmental and social equity and what learning experiences prompt these questions. This understanding is particularly crucial when examining students who have undergone specialized graduate education in humanitarian engineering, as it can help provide more targeted support for their professional commitment to the field. Ultimately, we address the following questions using a SCCT lens:

RQ1) In what ways are graduate students questioning their HE career expectations throughout HE graduate programs?

RQ2) How are HE academic and experiential learning experiences prompting students to question these career expectations?

Methods

To answer these questions, we studied graduate students enrolled in Humanitarian Engineering (HE) programs in the United States. We conducted multiple interviews with each student over the course of two years (2021-2023) and analyzed transcripts for instances when students reflected on questioning their HE career goals and what prompted their questioning. Our research protocol was

approved by the Institutional Review Board (IRB) at the University of Colorado Boulder (21-0207).

Context

We recruited students enrolled in seven graduate HE programs (six to ten students per program). Programs were chosen by compiling lists of 45 HE affiliated education programs and research centers in US Universities (Pieffer 2020). We then narrowed the list to only include the programs that had entire HE-focused graduate programs. Our final list of seven included programs with faculty who were willing and able to assist and provide feedback on recommendations. All selected HE programs had similar mission statements; an example is the mission statement of the HE program at the Colorado School of Mines: "*to educate engineers to serve communities by collaboratively identifying problems and providing solutions that are just, socially responsible, and sustainable.*" (CSM 2023). Selected HE programs were located across the United States and had experiential and academic learning components. Table 1, details basic descriptors of these programs.

Table 2-1 Program Descriptors

Program	University Size*	City Size	Region	HE Degree Offered
1	large	small city	West	Master's
2	large	midsize city	West	Master's
3	large	large city	South-West	Master's and PhD
4	medium	large city	East	Master's
5	medium	large city	East	Master's
6	large	midsize city	West	Master's
7	large	large city	South-East	Master's and PhD

* University size: large (>15,000 students), medium (5,000-15,000 students), small (<5,000 students). City size: large (>250,000 residents), midsize (100,000-250,000 residents), small (<100,000 residents).

Data collection

Forty-seven students were recruited through email advertisements circulated by program directors and professors. 36 - 46 students were interviewed every semester for two years, for a total of 165 interviews, and received the incentive of $20 gift certificates for each interview. The study sample consisted of master's and doctoral students from diverse racial, ethnic, and socioeconomic backgrounds. Students were at various stages of their graduate programs, ranging from those in their first few months to those with two years of experience. The cohort included 26 students who self-identified as White and were from high-income countries, and 19 students who either themselves or had at least one parent from a low- or middle-income country. Specific racial and ethnic data are not included to protect participant anonymity and to acknowledge the fluid and context-dependent nature of racial self-identification within this diverse international student population.

We utilized descriptive, ethnographic interview questions (Spradley 1979) that encouraged rich, detailed reflections and descriptions from students into their interests and confidence in HE, as well as how their educational experiences influenced their career aspirations. Interview guides were developed each semester and slightly altered based on the timing and specific context of the participant's progress in their programs. Initial interviews prioritized understanding of the participant's career goals and aspirations by asking them to describe their current goals and the story of how they developed. Subsequent interviews focused on capturing how students questioned and refined their career goals over time. We began with descriptive open-ended questions like, "How have your career goals changed?" to encourage reflection on any shifts they had experienced. To understand why students questioned their career paths, we then probed the four key aspects of SCCT through tailored questions. We explored mastery experiences by inquiring

about successes and challenges during HE experientials, and vicarious learning by asking about influential role models. Further, the impact of verbal persuasion from peers, mentors, and coursework was examined alongside students' emotional states during their mastery experiences.

While we aimed to interview all 46 students each semester, some were unable to participate due to other commitments. In cases where a student missed an interview but participated in a subsequent one, we asked them to reflect on their educational experiences and career goal pathway during the missed semester(s) as well. All interviews, regardless of the number a student participated in, underwent the same data analysis process. Audio recordings were transcribed using Trint (Kofman 2023) and imported into the qualitative coding software NVivo (Richards and Richards 2022).

Analysis

We conducted a thematic analysis of the interview transcripts following Braun and Clarke's (2006) established six-phase process. Themes were defined as patterns of meaning that emerged consistently across multiple participant interviews, with emphasis on patterns that reflected shared experiences or perspectives rather than isolated occurrences.

We coded interview transcripts to identify ways that students questioned their HE careers and what learning experiences prompted this questioning. First, we identified instances when students reevaluated their career expectations. An HE career was defined as a career that had some broad pursuit of addressing or mitigating social and environmental disparities through engineering. Our focus was on discerning moments when students contemplated their HE career expectations, including self-efficacy and outcome expectations, particularly those that acted as deterrents. We, therefore, coded interview responses into the code 'Questioning career expectations' whenever a

student questioned whether a HE career would help them attain their career goals, their ability to complete the necessary tasks within HE careers, or their ability to get an HE career. For example, the following quote, "*Your first semester of grad school is such a culture shock. I was learning so much about the harmful history with development* [...] *that we're recreating neoliberalism and colonialism. And I felt like I was so stupid to think that I* [could] *make a difference because it is all harmful* […] *it was a really hard time*", would be coded under, 'Questioning HE career expectations', because the student is worried about achieving their goals of social impact. We then inductively coded these instances into child codes that emerged. For instance, the example code was coded into the child node, 'Cost-Benefit Ratio', which described students who questioned if the harms of HE projects, such as colonialism, outweighed their potential to improve social equity. An overview of the deductive and inductive codes used to analyze how students questioned their career expectations is displayed in Table 2 in the Findings section.

Next, we deductively coded the learning experiences that triggered students to reevaluate their career aspirations into two standard pieces of HE graduate school: academic learning and experiential learning. Specifically, 'Academic Learning' encompassed all classroom activities, including required and elective courses undertaken during their graduate programs, assigned coursework, and seminars. Further, 'HE experientials', encompassed student attempts to address environmental or social equity through engineering, including through project-based learning, internships, capstone design projects, research, or fellowships. For instance, the example above was coded to 'Academic Learning' because they are talking about the influence of their coursework on their career goals. We then deductively sub-coded these experiences based on the four learning experiences described by Bandura in Social Cognitive Career Theory: mastery, verbal persuasion, vicarious, and emotional distress (Bandura 1997). The example passage would

then be sub-coded under ‘Verbal Persuasion’ because, through this coursework, the student reflects on the feeling she is persuaded that HE projects, like development projects, are neoliberal, colonial, and thus harmful. Some students' reflections did not exhibit a clear connection to HE academic and experiential learning experiences, and these reflections were deemed outside this research's scope.

After coding, we analyzed qualitative responses for how ‘Academic Learning’ and ‘HE experientials’, and the four learning experiences from SCCT, influenced questioning of career expectations. After completing and analyzing interviews over the two-year timeframe, we determined that we had reached theoretical saturation, finding that no new themes emerged regarding how graduate students questioned their career expectations and the influence of their experiences. Further, we ensured the validation of our findings by conducting a member check, wherein a manuscript of the paper was shared with all interview participants, and their feedback was sought to confirm the paper's accuracy and their resonance with our interpretations. This process validated our findings, as participants confirmed that the analysis accurately captured their experiences and perspectives.

Findings

Overview of the Ways Students Reassessed Career Expectations

Our analysis revealed three primary domains where humanitarian engineering (HE) graduate students questioned their career expectations. They questioned the impact potential of the HE field (98% of students), their personal capacity to create impact (96% of students), and the personal benefits and challenges of HE careers (87% of students). As shown in Table 2, when questioning the HE field's impact, students worried about engineering organizations' resistance to prioritizing social and environmental wellbeing, external barriers preventing infrastructure improvements in

marginalized communities, whether HE projects could cause more harm than good in marginalized communities (cost-benefit ratio), and the lack of goalposts for successful practices to follow. When examining their personal ability to create impact, students grappled with unease about engaging in communities as outsiders where they lacked cultural, linguistic, familial, or geographic connections; their concerns about the ability to enter and succeed in the HE job market; their identity as technically competent engineers, and their ability to influence engineering organizations to prioritize social and environmental wellbeing over traditional profit or innovation-focused metrics. Additionally, students questioned whether HE careers could provide satisfactory work-life balance, financial stability, and opportunities for building community and personal relationships and were concerned that they lacked an understanding of the day-to-day activities of HE careers.

Table 2-2 Percentage of the 46 students who questioned their HE career expectations

Students Questioned the Impact of the Humanitarian Engineering Field	Inflexibility of HE and Engineering Firms	External Barriers	Cost-Benefit Ratio	Lack of Goalposts for Improving the Field
	63%	57%	41%	35%
Students Questioned their Own Ability to Have an Impact	Working as an Outsider	Succeeding in HE Job Market	Engineering Identity	Activist Ability
	74%	63%	37%	26%
Students Questioned the benefits of the Humanitarian Engineering Field	Work-Life Balance	Financial Benefits	Ability to Build Personal Life	Understanding of HE
	43%	37%	35%	28%

Learning Experiences Shaping Career Expectation Reassessment

Next, we analyzed the experiences that led students to question their HE careers. Table 3 presents the different types of learning experiences that prompted students to question their career expectations during the two-year research period.

Table 2-3 Percentage of the 46 students who reflected on a learning experience prompting them to question their HE career expectations.

	Vicarious	Verbal Persuasion	Mastery	Emotional
Academic Learning	57%	54%	35%	15%
HE Experientials	57%	17%	76%	72%

Academic Learning

Classroom activities and discussions prompted questioning of career expectations throughout the four types of learning experiences. As shown in Table 2, 57% of students reflected on vicarious role models, 54% on verbal persuasion experiences, and 35% on mastery experiences, prompting them to question their HE career expectations. In this section, we refrain from discussing emotional distress due to its less frequent occurrence in student reflections.

Vicarious Learning: Having Access to Relevant Role Models (or Not)

Students began to question the impact potential of the HE field as their graduate coursework exposed them to numerous case studies of infrastructure and technology projects that, despite being implemented to improve social and environmental equity, proved ineffective, unethical, or unsustainable. Specifically, classwork exposed students to projects that failed in multiple ways: many were designed without input from the marginalized communities they aimed to serve, lacked understanding of local contexts, remained unused or unmaintained after implementation, caused

social tensions within these communities, undermined local economies, or perpetuated cultural imperialism.

Examples of such projects discussed across different programs included the failed PlayPump water system (Chambers 2009), the mismanaged humanitarian aid response to Haiti's 2010 earthquake (Echebarria 2023), and the detrimental economic impacts of international monetary fund projects (Cohen 2022). As one respondent described in the following quote, this abundance of failures ignited some students to doubt their expectations of impact from HE initiatives:

> *We've just been learning about projects that have failed. So, I kind of have a pessimistic outlook right now, but I'm trying to learn that there are ways to be successful.*

Further, students questioned the impact potential of the HE field and recognized the need for reform as they learned how engineering organizations remained constrained by traditional policies, cultural norms, and institutional practices. Students learned about organizations whose climate pledges, corporate social responsibility missions, or sustainable development values were a form of greenwashing or virtue signaling to gain public approval or funding opportunities. Similarly, one student talked about a class reading that revealed how the Peace Corps was initially established to benefit US citizens and enhance US public image, with little consideration for the marginalized communities it claimed to serve. Students also learned how financial restraints, top-down organization structures, or neo-colonial approaches to sourcing labor and materials from marginalized communities limited the transformative potential of engineering organizations to prioritize social and environmental equity. These examples led students to mistrust the social and environmental missions and value statements of engineering organizations, as illustrated by one student's reflection on corporate motivations to work with marginalized communities:

> *We had an article in class that was an evaluation of how multinational corporations have gotten involved with the bottom economic bracket of the world. And one* [corporation said]*, "We started integrating real farmers in a new way, so they would get a higher margin* [of the profit]*." I was like, "Oh yeah, this is cool."* [however] *then the* [reading] *would have these quotes that said basically "the best thing about working with people at the base of the pyramid is that they have no power to negotiate and will take whatever you give them."*

After studying numerous failed or problematic HE projects, students expressed a desire for role models, guiding frameworks, and clear objectives to help them assess whether they could have meaningful social or environmental impact through HE work. The scarcity of exemplary organizations, coupled with frequent exposure to unsuccessful projects, left many students feeling adrift in their career aspirations. This uncertainty was also reflected when faculty praised HE practitioners whose work students viewed as problematic, as illustrated in the following quote:

> *Somebody was coming to speak, and my professors were like, "This is the quintessential* [humanitarian] *engineer."* [...] *And her answers were weirdly flippant. She was like, "Yeah, I'm just kind of making it up as I go along. I don't really know about what my liability is here," and I was so genuinely upset. I was like, "This is the quintessential* [humanitarian] *engineer? I don't want to be like her.* [..] *That is white saviorism, so I don't feel like I've got great examples of what the career* [I want is].

Students also questioned the impact potential of the HE field as they learned about the many external challenges, ranging from immediate logistical obstacles to systemic issues, in case studies and their peers' experiences on HE projects that hindered social and environmental impact. At a

systemic level, students learned about challenges like the ongoing exploitation of resources by wealthy corporations in low-income countries. In response to these systemic causes of inequality, students began to question whether they should pursue law or policy rather than engineering to create a sustainable and effective impact. Students also learned about significant day-to-day challenges. For instance, one student reflected on a HE project that struggled to motivate a community to stop consuming polluted water when health impacts weren't immediately visible. The persistent challenges humanitarian engineers encounter by working in marginalized communities were highlighted by another student who observed how a project to improve sanitation infrastructure was hindered by inadequate transportation infrastructure:

> *We were* [learning about] *sanitation in South Africa.* [Here] *the rural areas weren't as easily accessible because the buildings weren't necessarily built by code, and trucks really couldn't get in there to get the waste out. So then the* [sanitation utilities] […] *don't even try to go there anymore.*

Finally, students questioned their personal ability to have impact as they learned through case studies and peers' experiences about the difficulties of working on HE projects in marginalized communities as outsiders. Students reflected on examples that raised concerns about engaging in communities where they lacked cultural, linguistic, familial, or geographic connections. They learned from others' experiences about both tangible fears, like taking jobs from more qualified individuals and disrupting community dynamics, as well as more existential fears about imposing outsider beliefs in communities even when projects are successful, as expressed by a classmate who worked in India:

> *One of my classmates who worked in India said, "*[...] *I was working with farmers and directing them to get help from this nonprofit. But I ended up filling in all the forms for them." She said, "we have given people power and agency, but we have taken away sovereignty." We have now conditioned the world to want the same lifestyle and have the same values as the United States, which is based on a model of individualism and consumption. So, now we have told the world what to want, and we have given them tools on how to go about getting that, but then it costs a lot of problems like climate change and wars, etc.*

Overall, HE students expressed concern about their social and environmental impact goals as coursework exposed them to many HE projects that didn't center sustainability or equity, and a shortage of positive examples to emulate.

Verbal Persuasion: Receiving Verbal Encouragement and Discouragement

Students questioned the impact potential of the HE field as classroom discussions and readings persuaded them to examine systematic faults in HE practices and structures critically. For instance, students reflected on classroom content that discouraged them from the merits of policies, cultures, and norms that were sometimes deeply rooted in the HE field. One student captured this growing disillusionment with the field's fundamental structures and desire for a role model on effective, equitable HE work, reflecting: "A big takeaway was development is inherently a racist, classist endeavor. Like, OK, then why are we all here?"

Students deepened their questioning of the HE field's impact as class discussions critiqued institutional processes embedded within HE organizations and funding structures. Students reflected on being deterred from various missions of HE organizations, including the Sustainable

Development Goals, for being heavily influenced by large institutions like the World Bank, UNICEF, and UNESCO and inadequately influenced by local communities. Other students reflected on being taught that HE funding mechanisms tend to be skewed, with organizations heavily reliant on grant funding and donations that come without any guarantee of meaningful impact. Class discussions showcased that only a fraction of grant funding reaches the intended communities. Further class discussions grappled with the paradox that HE jobs depend on the persistence of poverty and inequality, motivating HE organizations not to prioritize effectiveness, sustainability, and equity. Across these learning experiences, students reflect on feeling discouraged from joining the HE field because they were being discouraged from the merits of HE systems, norms, and cultures.

On top of learning the faults in the HE field, many students felt discouraged from pursuing their career goals because of the ongoing, seemingly permanent root causes of infrastructure inequality. Specifically, coursework exposed students to structural barriers to infrastructure equity, such as historical factors like trans-Atlantic slavery, ongoing trade regulations, international debt, imperialism, and capitalism. Compounding their concerns, coursework persuaded some students that climate change's imminent and long-term consequences on global equity would overpower other engineering attempts to improve social and environmental well-being. In response to these ongoing systemic causes of inequality, students began to feel persuaded that they should be involved in law or policy to have a sustainable and effective impact, as opposed to the engineering field. Other students, like the one quoted below, began considering whether focusing on climate change mitigation might offer a more effective means of safeguarding low-resource communities.

I've realized that international development is at the end of the issue. It's trying to address the consequences [..]*, whereas I think it would be more effective to start on the causes and try and mitigate the climate crisis before the impacts*

As these ongoing oppressive systems persist as seemingly insurmountable drivers of inequality, students, such as the one portrayed in the following passage, questioned the impact of all HE projects, perceiving them as inherently superficial or akin to mere "band-aid" solutions.

So, reading "The Divide" it talks about how capitalism is a huge driver of global inequality, […] *So then I really struggle* […] *capitalism is a driver of this. There's no way we're changing that.* [...] *How do you work in the field knowing these underlying issues are still there?*

Mastery: Experiencing Personal Successes and Failures

Students questioned whether they could solve HE problems effectively as they struggled to master the complex, open-ended nature of HE problems compared to traditional engineering coursework. Some students reflected on the contrast between their prior applied science undergraduate experiences, characterized by set formulas, boundary conditions, and well-defined goals, and the more fluid problem-solving landscape of humanitarian engineering problems. Specifically, in HE problems, it seemed impossible to create a solution or project that checked all the goals of being sustainable, economically feasible, historically conscious, and socially acceptable. This prompted students to question the feasibility of achieving projects that simultaneously fulfill multiple objectives. As seen in the following example, this was especially daunting for students when learning about real-world barriers where students may perceive themselves as powerless in the face of governments or corporations.

One thing for me is talking about how the industry has impacted water quality, [what do you do] *when a government doesn't have the capacity to regulate a mining operation* [...] *I wish* [classes] *would have talked about that* [scenario] *more because* [class problems] *were kind of just idealistic.* [giving problem statements like] *"there's a stream here and you pipe the stream to the community, and you give them some chlorine tablets and that's* [a successful project]*."*

Students also questioned their engineering competence or identity as they encountered challenges in HE classrooms, particularly those from non-engineering backgrounds. This was particularly problematic for students from non-engineering backgrounds who were enrolled in the HE programs, who experienced being overwhelmed in courses where they needed more prerequisite knowledge and struggled to solve technical problems or envision themselves as capable problem solvers in technical domains. Further, some students from non-engineering backgrounds expressed frustration when students from engineering backgrounds led and thus gained experience succeeding in the technical components of team exercises. For instance, one student quoted below expressed frustration with this pattern and felt there was a prevailing perception that mastering engineering processes and concepts, such as prototyping, should be confined to engineering students.

The other day, one of my professors was like, "Oh, do any of you have prototyping experience?" Prototyping is a very vast word. You can prototype anything. You can prototype on paper with drawings. [...] *And I was like, "I don't know how to use a 3D printer. " And she's like, "Oh no, you guys don't know how to do prototyping. Like, sucks you can't make things.* [instead) you can focus on the business models of all of this and [...]*"it was kind of frustrating that it's like other people can't learn engineering skills.*

HE Experientials

Experiential learning experiences in HE also prompted questioning, notably in mastery (76% of students) and emotional (72% of students), but also in vicarious (57% of students). Here, verbal persuasion did not play as large of a role but was associated with questioning in 17% of students.

Vicarious: Having Access to Relevant Role Models (or Not)

Through their experientials, students encountered more examples of HE practitioners, projects, and organizations that reinforced their doubts about the field's impact potential. HE experientials, like HE classrooms, exposed students to HE practitioners, projects, and organizations that students believed were ineffective, unsustainable, or inequitable. HE experientials prompted students to research failed HE projects and travel to marginalized communities where they saw the prevalence of past HE organizations' broken or unused infrastructure projects. These experiences led students to question whether the risks and likelihood of failure in HE projects outweighed their potential benefits, especially in marginalized communities. Their concerns included community-level risks, such as wasting community members' time and resources and damaging relationships between nonprofits and the local community. Further, in trying to find co-collaborators, research participants, or gain contextual knowledge of the location of HE experientials, students were exposed to HE organizations and engineering organizations that have non-existent or superficial social and environmental focuses. One student expressed the sentiment, "[Through this research] *I keep discovering that the global development industry is just so antiquated, and I deal with people that are just doing things because they've always done it this way".*

Students' experientials exposed limitations in how HE and engineering organizations engaged with marginalized communities, pushing them to question the field's effectiveness and their capacity to change these practices. For instance, some students designed projects and conducted research

without physically visiting their partner community, rarely soliciting community input, and questioned whether they should expect that disconnection in their future HE career. Other students noted a disparity in the depth of social and environmental justice discussions between their internships, jobs, and HE classrooms. As seen in the following passage, some noticed that organizations were limited to shallow social justice initiatives, such as the presence of a Diversity, Equity, and Inclusion (DEI) committee and initiatives to diversify new hires.

> *So, I think their concerns* [in the internship] *were more about the day-to-day experiences of minorities versus structural racism and colonial legacy, which is something I'm interested in fighting for.* [...] *Yeah, it was a bit superficial and talking just about DEI.* [...] *I remember* [there was] *one panel on imposter syndrome. They had three white American women and one foreign national man. And one of the questions asked was, how do you deal with being a woman of color in the STEM space? And no one could answer it.*

Students also observed the limitations of practitioners' time and focus, including how practitioners' prioritization of equitable, sustainable, or effective projects was limited by financial feasibility and grant availability. One student described how their tech innovation firm primarily focused on affluent neighborhoods because these neighborhoods had the economic capacity to afford such services. In contrast, another student reflected on their experience with a market-based development firm, which faced constraints in assisting the poorest communities as these communities had no excess revenue to pay for the firm's services.

Verbal Persuasion: Receiving Verbal Encouragement and Discouragement

Through conversations during their experientials, students felt pressured to lower their expectations about achieving social and environmental impact in the HE field. Students reflected on bosses, mentors, advisors, and peers advising them to prioritize goals of finishing a project or project phase, publishing papers, or completing grants. Here, cost and schedule limitations often took precedence over activities to better center the needs and desires of the community members. For example, the following student reflects on being pushed to focus on making a journal article over the ideals she learned to center in her coursework:

> [My] *Indigenous thought and theory class really questions the motives of Western research. And so, I feel like if I pursue research to publish it, I'm doing it at the expense* [...] *of whoever's community I'm talking about.* [But] *my mentor has driven a lot of my work right now, and she has goals of publishing that are more intense than I would like. So, I'm uncomfortable but just going along with that.*

Other students reflected on being told their environmental and social goals were unrealistic, with one student expressing in an internship interview being told, "*Basically, what I ended up hearing is like, yeah, the real world doesn't work like that*." Students also encountered more subtle forms of verbal persuasion, as captured by one student describing pressure to prioritize corporate constraints over social impact:

> *My boss also cares about getting things done well. Just that sometimes the conflict is that he's also trying to run the company. So, when it is taking a bit longer to get something done and that's* […] *delaying a payment or something, he can also get agitated.*

Mastery Experiences: Experiencing Personal Successes and Failures

Through their experientials, students faced direct failures in their attempts to address infrastructure inequality, leading them to question their effectiveness in the field. Specifically, some students were a part of HE experientials that had flawed designs and did not align with the sustainability, social, and equitable standards they carried. Students grappled with being a part of HE experientials that seemed unfeasible or pedagogically contradicted what they were taught was important, including being designed with minimal or no contact with community members, with little understanding of the local contexts, or for communities with significant hardships, such as civil conflicts and widespread drought. Frustration arose when HE experientials used processes HE courses previously taught them to be ineffective, unsustainable, or inequitable. For instance, the student below faced a contradictory situation. Previous courses had taught her to be wary of the potential harm caused by HE work due to its problematic history. Thus, she found herself in a contradictory situation when she was assigned to design a survey for a project in a disadvantaged community, that she felt dismissed the ethical concerns raised in her previous classes and lacked any logical connection to benefiting the partner community. The student expresses her frustration stating:

> [My intro development class] *was just like "guys don't even work in development."* [and my next class told us] *"You need to make surveys, so you can later put in data for evaluating your technology, which doesn't exist yet". Yeah, very contradictory information on what was going on and how to approach this.*

Even when students had control over their projects, they struggled with conflicting HE goals that made them question their ability to create positive change. For example, one student talked about how environmentally focused projects are often not profitable because they are anti-consumerist.

Another student expressed a desire to collaborate with grassroots organizations but felt constrained by the necessity to work with companies holding nonprofit status and a board of directors to attain external credibility and financial support. One inner conflict faced when trying to meet social and environmental goals is described by the following student:

> *I remember driving out in the village a lot and thinking about how we could make* [this solar project] *more sustainable* [...] *And thinking, "What's the most sustainable thing we could do?" And I was like, "Oh, it's what they're already doing. Anything we do is innately going to make it less sustainable for them. So* [...] *here I am trying to improve health outcomes through technology, but at the same time, that's like destroying the planet to some extent, even when it's solar?*

Internships also resulted in some students experiencing personal failures in advocating for organizational change to better center environmental and social wellness. Many students believed they lacked the age and experience to advocate for change effectively within HE organizations whether through initiating conversations with coworkers, influencing policy, or shifting company culture. Other students expressed concerns about their ability to decline work on engineering projects that they perceived as potentially ineffective or harmful to marginalized communities. These concerns led to heightened apprehension and self-questioning regarding their role in advocating for change in the HE or broader engineering field. When breaking down the specific types of questioning based on Bandura's primary learning experience categories, this study revealed an intriguing pattern: students are experiencing failures in trying to advocate for change but are not learning about the difficulty of this process through verbal persuasion and vicarious experiences. Given that students are directly affected by and reflecting on these challenges, there

is potential value in fostering more discussions and presenting examples of advocacy within engineering firms through non-mastery learning experiences.

Beyond questioning their long-term impact, students doubted their ability to manage HE projects and the effectiveness of the HE field as they encountered the day-to-day challenges of implementation. Students again discussed community behavior change as a formidable challenge. For instance, one student had trouble motivating a community to show interest in a drinking water infrastructure improvement project, particularly because existing water sources, though vulnerable, remain functional most of the time. Students engaged in research grappled with difficulties accessing sensitive data on hardships or inequalities and reflected on how institutions and interested groups may act as gatekeepers of datasets to maintain a favorable image. Students like the one quoted below reflected on how much more time and resources various stages of HE experientials, such as creating fruitful partnerships with experiential stakeholders, took than they expected:

> *My expectations were to get placed in a community that had requested some sort of assistance. And then, of course, in reality, it doesn't go according to that plan at all. I was placed in a community that didn't really have the partnership that my sector typically gets. So, a lot of my first year was spent trying to find community members who were interested in conservation work.*

HE experientials also exposed students to the difficulty of doing HE work with marginalized communities as an outsider without cultural, familial, or geographical ties. Experientials pushed students to reflect on the advantages of working in their own communities as they were driven to navigate gaining community acceptance, navigating cultural norms, overcoming language barriers,

addressing time zone differences, and easing their concerns about disrupting the local social dynamics. Some students felt their HE experiential did not provide the resources necessary to do HE work as an outsider and emphasized the importance of dedicating substantial time to understanding the community, acquiring language skills, and nurturing meaningful relationships as pivotal factors for project success. Some students shared their realizations about how complicated social hierarchy and prejudice can be in different cultures and the difficulty of spotting and navigating classism, colorism, or tribalism in cultures students weren't familiar with. In internships and jobs, students grappled with the unique relationship between the context and the organization they worked for. For example, one student had to navigate the historical grievances that a marginalized community harbored toward the government organization they work with because of the harmful past operations of that organization. Students who needed to use a translator during interviews expressed concern they were receiving only summarized versions of discussions and losing important nuances of the research participants' experiences. Additionally, students expressed frustration with work style differences in other countries. As seen in the following quote, students occasionally had to encourage community members to actively participate in the experiential, which led students to question the community's level of investment in the experiential.

> *Nothing* [of my research] *really began until three weeks after I was there. And it was very much me trying to push people along.* [...] *So I had kind of a mental crisis of like, what is this research and what is the purpose of this research* […] *Americans can be fast-paced. Other countries aren't. And so, you have to kind of, like, adjust to them while still advocating for yourself.*

Finally, students were exposed to failure in getting internships and jobs. Students reflected on struggling to search for HE positions as the name is more obscure than other engineering titles,

applying, not hearing back and feeling HE jobs were underqualified, being underqualified for HE positions that require years of engineering work experience, and seeing HE opportunities, like peace corps, unavailable because of the COVID pandemic. This pushed some students, like the one quoted below, to consider alternative career paths outside of HE, even if those paths did not directly center on social equity:

> *I think that the Climate change field in the US is growing very rapidly.* [...] *I still think that the humanitarian engineering space is very, very small and the sort of roles that exist that would align with my values are even smaller.*

Emotional Distress: Low (or High) Levels of Negative Emotions

Finally, students questioned the personal costs of a HE career as they experienced various forms of emotional stress during their experientials. Some students reflected on contending with isolating circumstances in HE projects that prompt them to question their capacity to establish connections and build a sense of community in HE jobs that involve extensive fieldwork. These students reflected on the challenges of forming friendships, fostering deeper relationships, or maintaining connections with loved ones back home while engaged in HE attempts. The linguistic and cultural barriers they encountered during travel further contributed to this isolation, as they struggled to engage in meaningful conversations and, at times, felt uncomfortable due to language barriers. Further, students had to grapple with feeling uncomfortable with their unexpected authority over projects, as well as the unwarranted belief in their engineering skills in marginalized communities, which students attributed to their nationality, degree, or race. Finally, some students, like the one quoted below, recognized that HE experiences could distance them from peers back home who may not fully comprehend or relate to their goals and efforts. The discrepancy between external

praise for their work, even in the face of unsuccessful projects, and the nuanced reality of their HE experiential accentuated this feeling of distance:

> *It's also ostracizing* [...] *People tell you what you're doing is great. People tell you, "I could never do that. I always want to do that," or "Here's money for this or whatever." And you know that* [the HE project] *is not working great, but nobody can even understand that you lived there, let alone the nuances of your work.*

Additionally, students grappled with the arduous task of balancing work and personal life during HE projects, a challenge compounded by the heavy emotional toll of witnessing global suffering and inequality. The emotional weight of hoping for project success led some students to extended work hours and difficulty disengaging from work at home. One student reflected on the perceived trade-off between work-related social impact and personal well-being in an HE Career:

> *You become a person overly identifying with your work. If you feel like you're making all this impact, you feel like your job is really important to other people* [...] *It becomes a lot of how people know who you are, how you understand yourself,* [...] *but at the end of the day, that wasn't sustainable for me.* [...] *I think it's extra hard if you're going to try to balance having a family.*

The emotional weight of research became particularly heavy as students listened to participants' hardship stories while knowing their research or project might not create tangible benefits for these individuals. As seen in the following quote, HE research sometimes pushes students to contend with a sense of exploitation, where students gain from their interactions with low-income community members, while community members were unlikely to benefit comparably.

> *One of the households that we interviewed,* [...] *his response to a lot of our questions was "Nothing, we have nothing." He was sitting outside while we interviewed him and had ripped clothes, was barefoot, and* […] *It really makes you think,* [...] *He stands nothing to benefit from this* [research].

Socially privileged and white students reflected on a heightened awareness of their identity and whether it made research participants more hesitant to engage with them. Students were worried that they could perpetuate mistrust between different racial or national groups and affect the dynamics with aid organizations if their research failed to impact participants' lives. Upon disseminating their research, students expressed concerns about accurately representing the perspectives of the communities they worked with. This reflection also prompted broader feelings of concern about whether being a white American or an outside researcher might inadvertently perpetuate colonialism and contribute to the white savior industrial complex.

Finally, HE internships prompted students to reevaluate their financial stress in HE careers and question if they needed to balance the financial goals of their future careers with their social impact goals. Some students received offers adjusted to the local cost of living or engaged in unpaid internships, which, to some students, highlighted the financial constraints of the HE field. Other students experienced a lucrative engineering internship at a more traditional corporation, which served as a stark contrast, leaving them to contemplate the trade-offs of their social impact desires.

Student concerns regarding work-life balance, financial constraints, and community-building predominantly stem from instances of heightened emotional distress during personal experiences in higher education HE activities. Conversely, students less frequently have these concerns prompted by verbal persuasion or vicarious examples. Given the prevalence of these concerns

among the students in this study, there is potential value in incorporating more extensive discussions and exploration of these topics in academic learning and providing students with role models with practical experience in managing work-life balance, financial matters, and community-building within the context of HE work.

Limitations and Future Research

As with all research, this study has limitations. Despite conscientious efforts to uphold objectivity, it is imperative to recognize that the researchers' perspectives, rooted in their identities as women from the United States with higher education degrees, may have shaped the interpretation of participants' narratives. This study was focused on the graduate student experience scope across 46 students in 7 HE programs. This population, and the timeframe of the study (2021-2023) may limit the experiences and influential factors captured. Further, future research could explore how HE graduates' career pathways evolve as they enter the workforce and engage with social and environmental equity issues in their work.

Discussion

This research reveals several key insights in the ways humanitarian engineering (HE) graduate education shapes students' career expectations and goals. We found that classrooms may be diminishing students' social and environmental impact expectations by highlighting a multitude of failed and harmful HE project examples as well as persuasive reasoning that the HE field cannot meet students’ impact goals. Students discussed feeling discouraged by the perceived difficulty, ineffectiveness, and wastefulness of the HE examples they were exposed to, as well as the challenging and ongoing root causes of inequality and infrastructure disparities, such as economic imperialism, which they did not feel equipped to address. These conversations and explanations of failures and root causes of inequality align with the increased discussion of the ineffective or

harmful HE works happening in the larger field (New York Times 2021; Peace Direct et al. 2021; *Poverty, Inc.* 2014).

While this academic learning may push students to reevaluate their impact career expectations, they may also be unique and valuable spaces in engineering education. Specifically, traditional engineering education has been criticized for overlooking systematic injustices when teaching about engineering failures and potentially influencing students to be less concerned about marginalized and disadvantaged populations (Rulifson and Bielefeldt 2017; Schneider et al. 2009). Students in this study contradicted past studies on traditional engineering education by heavily reflecting on the systematic injustices of HE and broader engineering fields and carrying a dedication to marginalized communities.

This research also found that HE experientials expose students to personal failure and an emotional toll when attempting to improve environmental and social wellness through engineering. Students in this study reflected on the importance of these experiences in understanding the current status of HE and engineering organizations in centering social justice and the day-to-day challenges of HE work. Graduate students' reflection on personal failure represents an important shift in engineering education. Specifically, scholarship on undergraduate HE experiences shows that these experiences can emphasize the growth of students above all else and can cultivate white saviorism, where socially dominant individuals are performing activism for emotional self-satisfaction while creating ineffective or harmful projects and relationships with marginalized communities (Birzer and Hamilton 2019; Jackson 2008). Indeed, other studies have shown that HE students can develop a self-image as problem solvers, which hinders their ability to critique their own work (Downey and Lucena 2007; Schneider et al. 2009).

Finally, these findings extend our understanding of how graduate education influences career pathways, particularly aligning with and extending Social Cognitive Career Theory (SCCT). The research illustrated the heavy connections between mastery, emotional, verbal persuasion, and vicarious experiences on student career expectations, adding to the limited literature that illustrates the impact of these types of experiences on career self-efficacy (Lent et al. 2017; Bandura 1997). Further, this research further validates the value of using SCCT to understand the career pathways of engineering students and, more specifically, HE students (Brubaker et al. 2017; Chubin et al. 2008; Lent et al. 2007).

Recommendations

Based on these findings, HE graduate programs would benefit from several changes to better support students' social and environmental equity goals. Programs should balance the vicarious and verbal persuasion learning experiences students are exposed to in class, making sure to balance failures with examples of success to allow students to visualize, emulate, and expand on successful projects in future careers. Further, this study highlights the importance of simultaneously encouraging student career goals while discouraging harmful and common systems in the HE field. Faculty may wish to reflect on how students can carry a critical understanding of inequality while maintaining motivation for a career in equity, perhaps by looking to social justice movements where activists must grapple with similar paradoxes in the permanence of inequality (Bell 1992).

While critiquing project failures and systemic inequities helps students develop as thoughtful HE practitioners, students need support for their career goals as they gain these mastery and emotional learning experiences. This study found that students desire additional support and frameworks when making trade-offs between making sustainable, historically conscious, financially feasible, and socially acceptable HE experientials. Other students desired more direction in advocating for

change in traditional engineering and HE firms. Students need structure to process and react to inadequate HE projects as they learn the realities and difficulties in addressing environmental and social wellness through engineering internships, theses, and school projects. Together, these recommendations aim to help programs balance critical awareness with career motivation while providing structured support for experiential learning.

Conclusion

In conclusion, this research delves into the crucial intersection of HE programs and the career goals of graduate engineers with a commitment to social and environmental equity. The study sheds light on the dynamic process of students reassessing their equity-centered career goals. By employing Social Cognitive Career Theory as a theoretical framework, the research identifies the pivotal role of learning experiences—mastery, verbal persuasion, vicarious, and emotional distress—in influencing students' expectations and aspirations. The research unveiled a more nuanced understanding of how HE graduate students question their ability to advance social and environmental equity through engineering.

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Chapter 3. Nurturing Transformational Resistance: How Humanitarian Engineering Education Shapes Students' Capacity to Challenge Systemic Inequality

Abstract

Background Humanitarian Engineering (HE) education programs train students to work alongside marginalized communities to improve infrastructure and technology disparities. However, HE education's impact on students' ability to identify and tangibly address systemic barriers to equity is unclear. The Transformational Resistance Framework (TRF) can illuminate how hegemonic educational structures (e.g., norms, policies, and practices) quietly shape students' ability to identify inequitable systems in their work and resist, subvert, and transform these systems to bring about material change.

Purpose/Hypothesis(es) This study explores how HE students develop the ability to challenge systemic inequality and how HE graduate education shapes this development.

Design/Method We interviewed 46 students from seven US-based HE graduate programs over two years, for a total of 164 interviews, on their educational experience, views on social justice and inequality, and career goals. To analyze the data, we used a grounded theory approach informed by the principles of the Transformational Resistance framework.

Results This research uncovered distinct behaviors that emerged as students began learning about and identifying inequitable systems and structures in engineering: some behaviors stifled resistance (such as maintaining emotional, physical, and social distance from HE project impacts), while others nurtured resistance (such as using multidisciplinary perspectives on social good to analyze and improve HE practices). Further, HE program structures - including policies, curricula, and programmatic norms influenced students' participation in these behaviors.

Conclusions This work contributes to understanding the relationship between HE learning experiences and HE students' ability to identify and act upon inequitable systems in engineering.

Keywords Humanitarian Engineering; Social Justice; Critical Theory; Qualitative; Student Development; Interviews

Introduction

Humanitarian engineering (HE) educational programs increasingly recognize the need to address systemic inequality — the interconnected structures (e.g., policies and norms) that perpetuate inequality — to achieve common HE goals, such as reducing disparities in infrastructure service provision (Burleson et al., 2023; Smith et al., 2020; Thomas, 2020). However, further research is needed to understand how HE education influences students' capacity to challenge systemic inequality (Reynante, 2022), particularly given research suggesting traditional engineering education may diminish students' concern with public welfare and receptivity to marginalized perspectives (Cech, 2014; Leydens & Lucena, 2009). Additionally, engineers have historically reinforced rather than dismantled inequitable structures (Costanza-Chock, 2020; Hickel, 2018; Yates & Murphy, 2019). While existing literature suggests a correlation between HE educational experiences and increased social consciousness among engineers (Budny & Gradoville, 2011; Litchfield & Javernick-Will, 2015), some scholars question whether common HE learning experiences adequately prepare students to move beyond theory to actively resist, subvert, and transform these inequitable systems in their everyday engineering practices (Nieusma & Riley, 2010; Niles et al., 2020).

Scholars in Critical Race Theory (CRT) have developed an established framework, the Transformational Resistance Framework (TRF), to examine how learning environments can either foster complacency toward inequitable structures or actively empower students to disrupt and reform them (Solórzano & Bernal, 2001). This framework illuminates students' ongoing efforts to create a more just world by connecting their justice-oriented aspirations to justice-oriented actions, particularly when they are confronted by inequitable or oppressive structures in engineering. These structures, though normalized and rendered invisible through dominant narratives, continue to

reinforce archaic racist and settler-colonial systems (Beth Clarkson et al., 2022; Deeb-Sossa & Boulware, 2022; Hannegan-Martinez et al., 2022). Furthermore, TRF highlights the importance that learning environments play in nurturing students' resistance behaviors, supporting them in critiquing structural oppression, and sustaining motivations for social justice.

This research contributes to scholarship on HE education and Critical Race Theory by directly examining how HE learning environments influence the development of resistance behaviors among engineering students. Drawing from 147 interviews with 46 students across seven HE graduate programs, we investigate: How do hegemonic norms, policies, and practices within HE graduate educational programs shape students' ability to challenge, disrupt, and remediate systemic inequities in their engineering praxis? What types of oppositional behaviors are cultivated due to these disciplinary norms, and how do they support or inhibit students' ability to confront and remediate systemic inequities for themselves and the communities they serve?

Background

The Mission of Humanitarian Engineering Education

Humanitarian Engineering (HE) education programs are growing in popularity in the U.S., with over 67 programs by 2020. Despite the variety of names they may adopt, community development, technology development, global engineering, or sustainable development (Smith et al., 2020), these programs share a common focus on prioritizing societal well-being.

This prioritization is achieved through learning about and working with marginalized communities, defined as groups facing systemic oppression or exclusion due to factors like race, ethnicity, gender, socioeconomic status, disability, or geographic location (Sensoy & DiAngelo, 2017). This includes communities from Low- and Middle-Income Countries (LMICs), which the

World Bank classifies as nations with a Gross National Income per capita that is less than 14,005 (World Bank, 2025). Through these efforts, HE education programs aim to address global challenges, including achieving natural hazard resilience and advancing the U.N. Sustainable Development Goals- particularly ensuring all communities have access to clean water and sanitation, reliable energy, resilient infrastructure, and reduce inequality between and within countries (Burleson et al., 2023; Smith et al., 2020; Thomas et al., 2021).

HE stakeholders increasingly recognize that achieving their resilience and sustainability goal requires addressing systemic inequality - the interconnected structures (policies, assumptions, biases, traditions, norms, definitions, and explanations) that perpetuate inequality (Sensoy & DiAngelo, 2017). For instance, a recent summit of HE industry leaders, innovators, and academics emphasized that sustainable development cannot be achieved without addressing systemic inequities (Burleson et al., 2023). Humanitarian engineers have been defined as as professionals who work to identify historical and systemic drivers behind inequitable access to essential services, such as water, sanitation, and energy (Thomas, 2020). Moreover, they are being called upon to cultivate work environments that encourage open critique of inequitable practices—such as discriminatory language and deficit frameworks—and to challenge inequitable policies, particularly those affecting career opportunities (Peace Direct et al., 2021). Finally, a collaborative effort involving 115 students, faculty, and practitioners highlighted the importance of developing justice-oriented engineering skills and sensibilities, including the ability to analyze historical and contemporary inequalities, examine the ethical implications and power dynamics of global development, and foster inclusive and diverse engineering teams as key learning objectives for HE students (MacDonald et al., 2022).

The field's increasing interest in addressing systemic inequality is crucial, especially considering engineering's historical tendency to inadvertently exacerbate inequitable access to technology and infrastructure services (Winner, 1980; Yates & Murphy, 2019). Traditional engineering design practices often exclude marginalized communities from decision-making processes, developing technologies and infrastructure that further marginalize or harm them. This is often not the result of intentional discrimination, but rather because these designs reflect the values and perspectives of those with the power to create them—predominantly individuals from privileged and often homogenous groups. For example, engineers have developed medical technologies that exclude gender non-conforming or disabled individuals, as well as digital platforms and algorithms in job recruitment or lending that perpetuate racial, gender, and socioeconomic biases (Costanza-Chock, 2020).

Further despite its humanitarian aims, HE often perpetuates the very systemic inequalities it seeks to address. HE projects and organizations can replicate historical legacies of colonialism, imperialism, and the transatlantic slave trade, as support often flows unidirectionally from former colonial powers to former colonies. Further they have a a history of denying marginalized communities—particularly those in peripheral and semi-peripheral countries—agency and control over their development (Lucena et al., 2010). This legacy continues today, as foreigners from imperial core countries often receive more power and compensation than local practitioners in HE projects in former colonies (Namubiru et al., 2018; Peace Direct et al., 2021). Moreover, HE efforts have been criticized for relying on superficial, or “quick fix” technological solutions that fail to address the underlying structures perpetuating global inequality. This approach has created dependency between countries, distorted local economies, and ultimately benefits high-income countries more than LMIC communities (Hickel, 2018; Sachs, 2019).

Considering these complexities, more research is needed to understand how HE education programs, themselves riddled with historically anchored norms, policies, and practices that reify colonial views of the engineer's role and relationship with social well-being and marginalized communties, shape engineering students' ability to identify, resist, and transform inequitable structures and systems, both in their profession and the greater world.

Current Practices in Humanitarian Engineering Education

HE programs train students to address engienering disparities through a combination of multidisciplinary coursework and experiential learning. Coursework typically emphasizes a broader societal context of engineering through a multidisciplinary curriculum incorporating social and environmental science (Thomas et al., 2021). Experiential learning opportunities included research projects, internships, and infrastructure projects that focus on designing, implementing, and monitoring technology solutions. These experiential learning activities often involve "partner communities" as students directly collaborate with leadership, citizen groups, non-profits, and other entities from marginalized communities facing infrastructure and technology disparities.

HE program structures warrant close examination, particularly given concerning trends in engineering education. Studies suggests that as undergraduate engineering students progress through their studies, they become less concerned with public welfare issues, such as understanding the societal impact of technology, contributing to social improvement, and helping others in need (Cech, 2014). Further, engineering curricula can hinder students' value of marginalized perspectives (Leydens & Lucena, 2009) and lead some students to leave the field due to perceived misaligned beliefs around social responsibility (Rulifson & Bielefeldt, 2017).

Encouragingly, research indicates that HE education can foster more socially conscious aspirations in engineers. Professionals and students involved in the HE organization, Engineers Without Borders (EWB), were more motivated to pursue engineering for social good than non-members (Litchfield & Javernick-Will, 2015). Additionally, students involved in HE senior design projects showed a greater willingness to sacrifice higher salaries for socially impactful careers than their peers (Budny & Gradoville, 2011). Finally, engineers who received training on their responsibility to public welfare, a common component of HE education, showed a greater understanding of their role in protecting public health and safety and recognizing the social and ethical dimensions of their work (Cech, 2014).

Furthermore, case studies have identified specific pedagogical approaches within HE education that show promise in teaching and normalizing student behaviors conducive to challenging systemic inequality. For instance, a study (Reynante, 2022) on the "design-for-justice mindset" found students developing the capacity to understand and challenge structures that perpetuate inequality during a semester-long HE project through four key learning processes: drawing upon prior experiences with inequity, connecting to course content, imitating experienced team members, and empathizing with community members. Additionally, another study (Leydens & Lucena, 2009) demonstrated that when HE students were taught to engage in intentional, community-supported, and context-sensitive listening with community partners, they became more aware of potential biases to overlook community desires. While these case studies offer promising insights, their limited scope and duration underscore the critical need for large-scale, multi-year studies across diverse institutions (Reynante, 2022).

Indeed, cross-programmatic research is essential, as other HE education research also highlights challenges in fostering engineering practices that enable meaningful student engagement with

inequality. Niles et al. (2020) argue that incorporating instruction on the social context and impact of engineering, while common in HE coursework, does not necessarily lead students to critically examine the structures causing privilege and marginalization or consider the role of broader systems of inequality like neocolonial power, imperialism, and white supremacy in engineering (Nieusma & Riley, 2010). Further, HE students have reported feeling frustrated and disengaged when faced with complex and ambiguous ethical dilemmas, including those related to systemic inequality (Niles et al., 2018).

Finally, scholars caution that HE experientials can unintentionally reinforce harmful student behavior that replicates power imbalances and neo-colonial practices between students and partner communities, potentially undermining community autonomy (Birzer & Hamilton, 2019; Nieusma & Riley, 2010). While many HE programs are actively working to increase diversity within their student body, many face challenges in this area (Thomas et al., 2021). Regardless, it is important to acknowledge that power imbalances often exist between all HE students and partner communities due to factors like race, nationality, or class.

In sum, existing scholarship highlights both the potential and the challenges of HE education in cultivating meaningful student engagement with systemic inequality. However, we lack an understanding of the influence of HE education on students' ability to challenge systemic inequality. To clarify this relationship, this research employs a longitudinal, multi-institutional analysis to examine how HE graduate programs shape students' engagement with systemic inequality. Further, to explore how students' behaviors relate to challenging systemic inequality, this study utilizes a theoretical lens that centers students as agents of societal change, specifically Critical Race Theory.

Theoretical Frameworks Employed

Critical Race Theory

Critical Race Theory (CRT) is an academic field dedicated to identifying and dismantling interlocking systems of inequality, such as racism, sexism, and classism, that maintain the subordination of People of Color (D. A. Bell, 1995; Ladson-Billings, 1998). Within this mission, CRT scholars develop frameworks to explore how individuals, particularly students, can challenge and change these systems. CRT utilizes these frameworks by adhering to five fundamental tenets, as seen in Table 1 below.

Table 3-1 Critical Race Theory Tenets

Tenet	Description
Recognizing and analyzing systems of power	CRT identifies and critiques inequitable and hegemonic structures, including norms, policies, and practices, that reinforce racist or settler-colonial systems (D. Bell, 1992; Crenshaw, 1989; Huber & Solórzano, 2015).
Challenging dominant ideologies	CRT examines prevailing norms and policies perpetuating systemic inequality, even those presented as logical, socially just, or aligned with equality goals (Davis, 2019; Solórzano, 1997).
Committing to social justice	CRT actively works towards dismantling racist and other oppressive systems, striving for a more just and equitable society (Solórzano, 1997).
Centering lived experiences of people of color	CRT recognizes that the lived experiences of marginalized communities, particularly people of color, are crucial for understanding the current conditions of racism and neocolonialism (Hubain et al., 2016; Solórzano & Yosso, 2002).
Utilizing an interdisciplinary approach	CRT draws on scholarship from various fields, including ethnic studies, women and gender studies, and whiteness studies, to better understand power dynamics and the intersections of various social identities (Yosso, 2005).

Transformational Resistance Framework

The Transformational Resistance Framework (TRF) examines how students identify, subvert, and transform oppressive structures in education (Solórzano & Bernal, 2001). Developed initially to understand how students of color resist racist educational structures, TRF has expanded to analyze how students actively challenge various interlocking forms of systemic inequality, including

racism, classism, nationalism, and neo-colonialism (Beth Clarkson et al., 2022; Chen, 2020; Deeb-Sossa & Boulware, 2022; Solórzano & Bernal, 2001). In the context of this study, the TRF can illuminate how students identify, subvert, and transform archaic and neocolonial structures in the HE field.

Resistant Behaviors to Systemic Inequality

The TRF illuminates how students actively resist systemic inequality through oppositional behaviors that challenge institutional and societal structures—from norms and rules to authority and expected conduct (Solórzano & Bernal, 2001).Students engage in oppositional behaviors in various ways, such as ‘talking back,' 'willed not learning,' refusing to code-switch, or challenging authority. As shown in Figure 1, these oppositional behaviors can be forms of resistance when informed by either a critique of social oppression or a motivation for social justice.

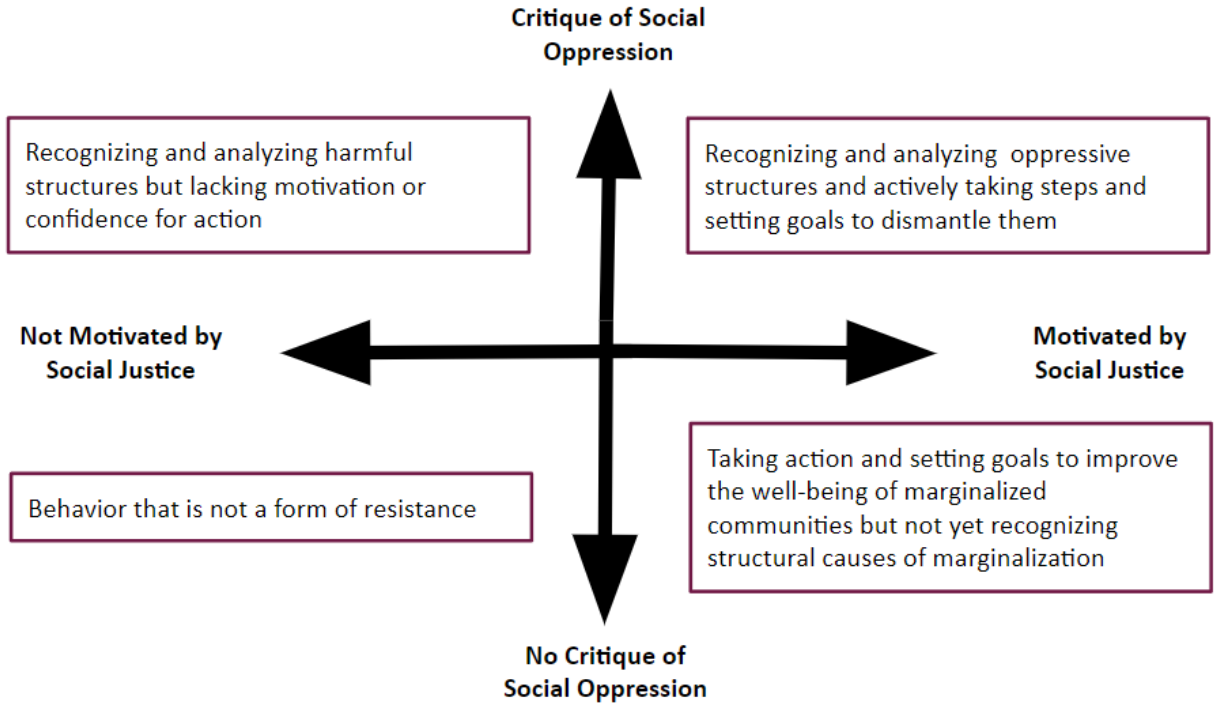

Figure 3-1 Transformational Resistance Framework

The vertical axis of Figure 1 was developed by scholars and educators who recognized that a critique of social oppression often drives students' oppositional behaviors. These behaviors are considered forms of resistance, as they indicate that students are beginning to identify the interconnected structures that exploit, silence, and marginalize certain groups while privileging dominant ones (Sensoy & DiAngelo, 2017). For example, students may engage in oppositional behaviors, such as verbally disrupting a lesson or purposefully checking out and not listening to a lesson, when they recognize that their educator repeatedly undervalues or dismisses the contributions and perspectives of students of color, reinforcing preconceived notions about their abilities and backgrounds. Such behaviors emerge as students learn about, question, and challenge harmful policies and norms within their educational programs and the broader world (Hannegan-Martinez et al., 2022).

The right half of Figure 1 was developed to reflect that students often engage in oppositional behaviors due to their motivation for social justice—specifically, a desire for equitable access to resources, opportunities, and liberties for all, as well as the empowerment of marginalized groups (Chapman, 2013; Solórzano & Bernal, 2001). This also constitutes a form of resistance, as a student actively resists the unequal outcomes produced by systemic inequality. For example, a student who notices their peers struggling in class may organize study groups to support them, fostering more equitable academic outcomes within their school (Hannegan-Martinez et al., 2022; Solórzano & Bernal, 2001).

An example of transformational resistance can be illustrated by the previous scenario of a student who recognizes that their educators consistently undervalue the contributions of students of color, thereby perpetuating deficit narratives. Rather than disengaging from the class or verbally challenging their teacher to belittle them, the student channels their energy into challenging the

deficit narrative itself. For instance, the student might thoughtfully share their perspective or provide resources that highlight the impact and pervasiveness of this culture to their educator, post about the issue on social media to disrupt the acceptance of harmful narratives, or even shape their career aspirations to become an educator who actively practices inclusive teaching. This oppositional behavior is characterized by strong self-awareness, purposeful questioning, self-advocacy, and multicultural understanding (Beth Clarkson et al., 2022; Chen, 2020; Hannegan-Martinez et al., 2022).

Students engage in all four types of oppositional behaviors in a fluid rather than fixed manner. Indeed, students often engage in all forms of oppositional behavior shown in Figure 1 concurrently, varying their critique of social justice and motivation for social oppression across different contexts and in response to the various oppressive structures they encounter (Hannegan-Martinez et al., 2022). This includes concurrently engaging in non-resistance behaviors, for instance, challenging an unfair grading policy simply because it affects them personally, without connecting it to broader systemic issues or social justice concerns. Because of this fluidity, the potential for growth in all students, and the value of students having an agency through engaging in transformational resistance, Critical Race Theory stresses the importance of nurturing the resistance capacities of all students through supportive educational environments.

The Impact of Education on Oppositional Behaviors

CRT scholars view all forms of oppositional behavior through the metaphor of 'seeds of resistance,' which have the potential to develop into transformational resistance through educational environments that nurture both a motivation for social justice and a critique of social oppression (Hannegan-Martinez et al., 2022).

Learning environments can stifle these seeds of resistance in various ways. For instance, educational programs may punish and mislabel students of color's resistance behaviors as deficits (Annamma et al., 2016; Milner, 2013; Noguera, 2003). Furthermore, when students critiquing social oppression are not adequately supported in becoming motivated for social justice or in disrupting the structures they critique, they can experience frustration, apathy, or resignation, leading to disengagement or even counterproductive actions like dropping out of school (Solórzano & Bernal, 2001). Moreover, students motivated by social justice may blame themselves, their families, or marginalized cultures for adverse social and personal conditions when not given the tools to critique the structural roots of inequity. These students may feel compelled to work within the bounds of the existing social system (Solórzano & Bernal, 2001).

In contrast, learning environments can also nurture oppositional behaviors towards powerful forms of resistance. Classrooms have achieved this by helping marginalized students reflect on and analyze their acts of resistance, prioritizing their lived experiences and dignity, fostering personal growth and the potential for collective change (Bernal & Aleman, 2016). Solorzano & Bernal (2001) further suggest that nurturing environments include a culturally sustaining curriculum that promotes cultural pluralism, authentic caring from faculty to students that honors their mutual humanity, and a commitment to social transformation that recognizes young people as agents of change. Others emphasize the importance of students learning to critique both systems of oppression that harm themselves and those over whom they may hold privilege (Covarrubias & Revilla, 2003).

Scholars have predominantly studied nurturing education programs for marginalized students as they navigate and challenge oppressive structures directly harming them and their communities. However, the traits associated with transformational resistance—motivation, empowerment,

curiosity, self-advocacy, and multicultural understanding (Beth Clarkson et al., 2022; Chen, 2020; Hannegan-Martinez et al., 2022)—are valuable for all students in resisting systemic inequality. Recent scholarship argues for the importance of students developing their ability to resist systems where they may hold positions of privilege, such as Latino male students challenging structures that harm Latina women (Covarrubias & Revilla, 2003). Given how intersecting racial, class, and nationality privileges (Tanner, 2018) significantly shape lived experiences, more research is needed to utilize the TRF to understand how learning experiences can nurture or stifle students' development toward resisting and transforming inequitable structures they have privileges over. This includes engineering students working to address inequitable policies, norms, and cultures that harm marginalized communities facing infrastructure disparities.

Methods

Study Design

We adopted a constructivist grounded theory methodology to investigate how Humanitarian Engineering (HE) education can influence student compliance with or resistance to systemic inequality (Case & Light, 2011; Glaser & Strauss, 1967). This methodology is valuable for further developing existing theories for understanding understudied populations with unique characteristics (Creswell & Poth, 2024; McCall et al., 2021). In this context, it is particularly useful for studying HE students, who have distinct socially minded career motivations. It also provides an opportunity to generate new theoretical insights for the Transformational Resistance Framework (TRF) by examining how education influences students' resistance to oppressive structures in which they hold privilege.

We used the TRF to develop our sensitizing concept, which in grounded theory research, serves as a foundational guide, focusing data collection and analysis on specific areas of interest (Bowen,

2006; Charmaz, 2014; McCall et al., 2021). Our sensitizing concept, "student resistance," was defined by and focused our research on students' experiences, reflections, and surrounding influences when critiquing social oppression and/or expressing motivation for social justice.

Finally, all research procedures were conducted in accordance with IRB protocol 21-0207.

Data Collection

We recruited 46 students from seven graduate programs (six to ten students/program) in the United States. Programs were selected through a systematic process: first identifying 45 HE-affiliated education programs and research centers (Pieffer, 2020), then narrowing to those offering complete HE graduate degrees. The final seven programs had faculty available to provide feedback and shared similar mission statements of educating engineers towards 'collaboratively identifying problems and providing solutions that are just, socially responsible, and sustainable' (CSM, 2020). Students were recruited via email advertisements distributed by program directors and professors and received $20 gift certificates for each interview as an incentive. The student cohort consisted of both master's and doctoral programs, representing various stages of their graduate programs (from the first few months to two years of experience) and a range of backgrounds. This included 26 students who self-identified as White and were from high-income countries, 19 students who were from or had at least one parent from a low- or middle-income country (LMIC), and one student of color who was neither from nor had a parent from an LMIC.

Over two years, we conducted 164 semi-structured interviews with the same cohort of students, averaging three interviews per student each semester. These interviews, lasting approximately 60 minutes each, were transcribed using Trint (Kofman, 2023). Guided by our sensitizing concept ("student resistance"), we developed interview guides that elicited rich personal narratives on students' experiences, reflections, and influences in resisting inequitable structures.

To identify moments of resistance, we regularly inquired about students' behaviors and aspirations, including within their HE experiential learning activities, career goals, and perspectives on the HE field's capacity to benefit marginalized communities. We specifically probed their reflection on their past semester to assess their critique of social oppression, asking how concepts like 'ethics, racism, neo-colonialism, and power dynamics' influenced their experiential work, career goals, and overall perception of HE. To understand their motivation for social justice, we inquired about their perceived confidence levels and ongoing actions to advocate for marginalized communities through their career goals or experiential work. Finally, we inquired how various aspects of their learning environments- such as coursework, media, mentors, peer conversations, and school services—influenced their perspectives, aspirations, and behaviors during their learning experiences and career goals.

While consistently exploring core themes around our sensitizing concept, our interview questions evolved over time in response to emerging themes and students' program progression. For instance, as students advanced to thesis work and internships, we adapted questions to explore how they applied their developing critique of inequitable systems in these new contexts.

Data Analysis

Using grounded theory analysis enabled us to connect our interview findings to conceptualize a framework that connects Humanitarian Engineering graduate education to students' resistance to systemic inequality. Transcripts were analyzed using NVivo software (Richards & Richards, 2022). All identifying information was redacted, and students were assigned pseudonyms to ensure participant confidentiality.

Interview segments were initially coded using our sensitizing concept, "student resistance." This coding was done broadly, capturing both subtle moments of students beginning to question a

practice as harmful to marginalized communities or expressing desires for social change and more overt expressions of resistance. Table 2 presents our initial coding dictionary with illustrative quotes.

Table 3-2 Initial Coding Dictionary

Student Resistance	**Example Quote**
Motivation for social justice	[I have] *a sense of equity and solidarity with the global population … 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 … that's my motivation.*
Critique of social oppression	*One of the biggest issues with these international projects is not promoting autonomy and having the community involved with the project … I* [learned that] *the word development is rooted in … promoting the global North's hegemony over the Global South.*
Motivation for social justice and critique of social oppression	*Why do I not want to seize power? … I've had the opportunity to meet so many people… who were much smarter, … and more thoughtful* [than me] *… I feel there are … enough white men* [in positions of power].

Next, we conducted open coding (Strauss & Corbin, 1990), meticulously examining each interview segment coded as "student resistance." This line-by-line analysis revealed preliminary themes related to students' oppositional behaviors toward inequitable structure. Specifically, we identified themes in students' internal processes during oppositional behaviors (such as their reasoning, conflicts, and decision-making) and their responses to external factors (including course content, faculty guidance, media messages, and peer interactions). Throughout coding, we documented emerging questions, areas requiring clarification, and potential refinements to the preliminary themes.

The subsequent analysis stage involved axial coding, where we refined our coding tree by identifying commonalities and relationships among the preliminary themes. Two dominant and

opposing axial codes emerged (Table 3): internal processes and external factors that either 1) nurtured or 2) stifled students' critique of social oppression and motivation for social justice.

Table 3-3 Axial Coding Dictionary

Axial Code	Definition
Constrained Seeds of Resistance	Student behaviors and surrounding structures that discouraged, confused, or limited students from recognizing and challenging systemic inequality
Nurtured Seeds of Resistance	Student behaviors and surrounding structures that encouraged, clarified, or enhanced students' toward recognizing and challenging systemic inequality

Through iterative coding and analysis, we developed a theoretical framework (Figure 2) showing how students' engagement with systemic inequality is influenced by their HE learning experiences.

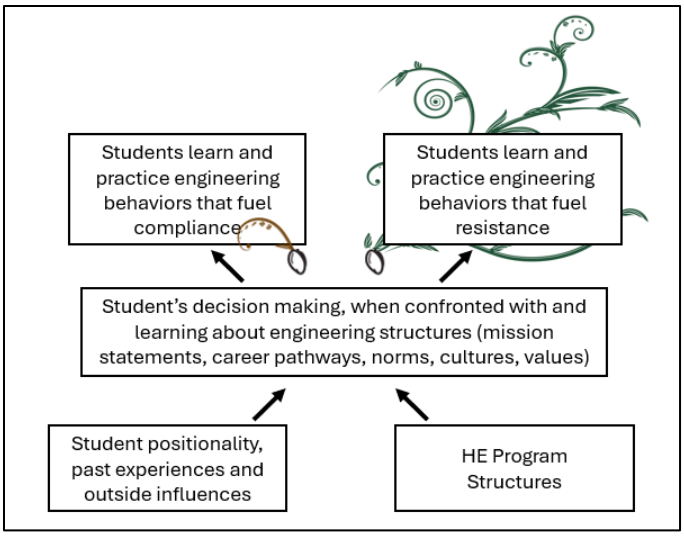

Figure 3-2 Influences on Student Resistance and Compliance in HE Education

Students confront and learn about various engineering structures during curricular activities, internships, and experiential learning experiences. In these moments, students consider whether to engage in oppositional behaviors - either critiquing these structures for perpetuating inequality, or actively resisting the inequitable outcomes they produce. HE program structures, interacting with students' positionality, can either motivate students toward engineering behaviors that fuel compliance with existing systems or support students in developing oppositional behaviors that

fuel resistance to inequitable systems. The following sections examine the engineering behaviors that emerged from this study and how program structures encouraged their development.

Findings

Behaviors that Inhibit Student Resistance to Systemic Inequality

This study identified three engineering behaviors, detailed in Table 4, that emerged in HE educational experiences that fueled compliance with inequitable structures rather than opposition to them. The following section uses narratives of student experiences to examine these behaviors and explore how different program structures motivated students toward compliance rather than resistance.

Table 3-4 Key Behaviors Hindering Resistance to Systemic Inequality

Behavior	**Example**
Prioritizing individual, academic, organizational, or ideological goals over partner community well-being and self-determination	*I definitely remember wanting to join EWB because I wanted to travel… I'm embarrassed about that now, but that is the truth.*
Maintaining emotional, physical, and social distance from the ongoing impact of HE partnerships and projects on partner communities.	*I wrote a grant…for an adult literacy class. … Unfortunately, this was towards the end of my service … I wish I had written it sooner so I could have monitored it. But unfortunately, I have no idea how it's going.*

Relying on personal intuition and peer discussion rather than external or established guidance on understanding social justice and inequity.	[My] *professor talked about environmental justice and the way he approached it ... He just put up a poll and then had us type in examples that we could think of* [for] *environmental injustice. And then it was like, OK, time to break now that we've read through this list.*

Prioritizing Individual, Academic, Organizational, or Ideological Goals

The first stifling behavior we observed was students rationalizing and acting on decisions to value academic, organizational, or individual objectives above partner communities' needs and self-determination.

James, a white student of US nationality, led a university-sponsored experiential, developing a portable database to provide educational resources to under-resourced schools and testing it with a partner community in Southeast Asia. He initially demonstrated seeds of resistance through a burgeoning critique of whether the project's goals aligned with the partner community's educational needs:

> [My team] *needs to prove that this device works so that it can be effective in many contexts around the world. Theoretically, that's the grand picture our* [university] *talks about*…[…] [This device] *might actually be less than helpful for a lot of these* [partner community] *schools. There's just a lot of quirks and…It might slow things down for a couple of teachers. That's another question in ethics, right?*

James's reflections reveal a growing disconnect between the socially minded HE goals espoused by the university, "the grand picture," and the potential negative on-the-ground impacts of the project, "less than helpful...slow things down." He was beginning to critique a neocolonial tendency to prioritize the abstract goals of dominant institutions over the concrete needs and agency of marginalized communities, which were effectively serving as testing grounds.

Simultaneously, while confronting decisions about redirecting the project's scope and focus, the structures of his learning environment persuaded and rewarded him to prioritize institutional goals over community wellbeing. Multiple institutional pressures shaped the project's mission - his tuition funding was tied to the program, his mentors and faculty championed the existing approach, and his role was framed around creating peer-education experiences. He described this tension: 'There is this weird dynamic of not trying to overstep and take over this assignment, [which was] already an agreed upon thing... I don't want to be disrespectful to [the faculty in charge of this project].” The project's timeline and communication protocols further limited James's ability to critically examine the project's impact - after a year of minimal communication with the partner community, he felt constrained during his short-term visit by time limitations and pressure from the students he mentored to deliver on the original mission. Finally, James began to internalize the program's culture, rationalizing that the device's potential transformative impact outweighed any immediate negative effects on the partner community. His statement evidences this: 'I know in my mind, this [community] is just the context we have chosen to prove our device.”

Programmatic structures—including funding mechanisms, academic requirements, and research expectations—often incentivized students to prioritize singular, immediate, and decontextualized institutional goals over the well-being of marginalized communities. Students experienced both internal and external pressures to focus on these goals, driven by faculty influence, concerns about

grades and graduation timelines, and aspirations for success in academic and research careers. Many students rationalized compromises in community impact by emphasizing the personal and professional benefits of their HE education, framing these trade-offs as necessary for their long-term humanitarian contributions. This justification was frequently couched in HE-centric altruism—the belief that their learning and career advancement would ultimately serve marginalized communities in the future. As a result, program structures often led students to divert time and resources away from community-level engagement, such as local dissemination efforts and workshops, in favor of academic outputs like journal publications and project completion reports.

The behaviors encouraged by HE program structures extended beyond academia and into the professional engineering workforce, where similar organizational pressures reinforced compliance over resistance. A white American student, Catherine grappled with the normative pressure to conform to her coworkers' decisions rather than advocating for community well-being during her computer science internship. She reflected, *"I expect pushback...for telling someone not to do something unethical...If I were part of a project that had social issues and shouldn't continue...it probably won't bode well for me in social circles...So* [speaking up] *feels like an occupational hazard."*

Disengagement and Irresponsibility in HE Partnerships

The second stifling behavior students described was maintaining emotional and practical detachment from their work's impact on partner communities, which was fostered by both willful ignorance of project outcomes and emotional avoidance of accountability for negative project outcomes.

This can be illustrated through Julia's experience, a student of color with US citizenship who traveled with a team of vaccinated students to an unvaccinated Indigenous community during the ongoing COVID-19 pandemic to conduct a needs assessment for future collaborations. Upon returning, Julia learned of a COVID-19 outbreak in the community. She demonstrated seeds of resistance when she began questioning the underlying assumptions and policies that allowed her to travel without considering the potential health risks, stating: *"We hadn't even thought about asking our project partner, whom we intended to meet if they were vaccinated…And so I was like, 'How did we miss this?'"*

Julia's concerns come from the disconnect between socially-minded HE goals (e.g., completing an infrastructure project for future equity) and the immediate, on-the-ground practices (e.g., risking community health during a pandemic). She was witnessing the oppressive norm of adhering to only the safety and acceptability standards of socially dominant groups with access to healthcare and vaccines, even in contexts where these standards expose marginalized communities to unnecessary risks.

While considering whether to take responsibility for and work to transform the project approach that endangered the partner community, programmatic structures encouraged Julia to maintain an emotional distance from the health risks faced by the community. The hierarchical nature of the project pressured her to defer to her faculty advisor's decisions, and she recalled, *"*[I] *kind of got peer pressured into traveling out there ... and I completely trusted the faculty's green light on going. And it was… necessary to getting the project rolling… what we were going out there to do couldn't be done remotely."* This quote illustrates how the programmatic culture framed certain interventions as *"necessary,"* effectively overriding critical discussions about whether traveling at that time was ethical or responsible.

Lacking a support network or framework to process her discomfort, Julia attempted to suppress her emotional distress. She admitted, *"It was very, very shocking to me... When I came back, I tried to just shove it off... I tried to shake that feeling* [of being culpable]*."* To rationalize the risky behavior, she reassured herself by noting that no students on the project team appeared sick—mirroring a neocolonial pattern of absolving oneself of responsibility when immediate, visible consequences are absent.

Finally, when Julia began vocalizing her unease, she encountered further resistance. The institution's continued post-trip emphasis on travel made her efforts at resistance exhausting, leading her to question the possibility of challenging the project's traditional and deeply valued timelines and structures. She described this ongoing tension: *"Our program is really pushing to travel again. And a lot of us are not comfortable with the risk of being vaccinated people going into a community of unvaccinated communities, where they don't have health infrastructure. And so we've been like kind of in this power struggle right now with some of our faculty… We get that it's important to travel… and* [that] *is like traditionally how the program was* [structured]*."*

Many structural elements of HE experientials enabled students to maintain emotional distance from their work's impact. First, the fragmentary nature of experientials' project scopes, which typically focused on isolated components like assessment trips or design phases, allowed students to become intellectually and emotionally disconnected from their projects' long-term implications. Second, misaligned communication processes with partner communities - stemming from cultural and linguistic barriers, geographical distance, and limited communication channels - allowed students to remain ignorant of their projects' ongoing effects. Finally, when confronted with evidence of their work's ineffectiveness or potential harm, some students, like Julia, actively

suppressed feelings of responsibility and regret rather than engaging with these uncomfortable realizations.

The culture of emotional and practical detachment from project impacts manifested in students' professional work opportunities. For instance, Nicole, a white American student working on water pump implementation in a low-income country, cared deeply about increasing global water access. However, her narrative of what constitutes engineering work included detachment from project outcomes, where greater involvement was viewed as potentially inappropriate or overstepping community boundaries. She stated, "I don't know [how the wells are doing]...The [community should] run their water committee however they want to. I'm just an engineer. [The space I occupy is limited to] telling them this is a good place to drill, and that isn't."

Insularity and the Absence of External Engagement in HE Social Justice Comprehension

The third stifling behavior the student described was relying solely on personal reflection and peer discussion to understand concepts of social oppression and justice rather than engaging with external expertise or marginalized communities' perspectives in conceptualizing issues like equity and decolonization.

For instance, Sue, a student of color and of US nationality, worked on an HE experiential where she and her team designed a software tool for an indigenous partner community from a low-income country. Initially, Sue demonstrated seeds of resistance behavior through her active motivation to co-create the software with the partner community. She recognized the oppressive project structure of HE practitioners imposing their will and values on marginalized communities by designing, building, and simply "dropping off" technology without community input. Motivated to resist this

structure, she dedicated hours each week to understanding "co-creation" and developing a process to integrate the partner community into the project design.

However, while trying to structure a collaborative project approach, her learning environment steered her toward relying almost entirely on peer discussion and personal reflection to define what collaboration meant. Her research methods course, for example, assigned experiential teams to reflect amongst themselves on implementing co-creation, inadvertently teaching students that their limited perspectives were sufficient for defining ethical HE practices. After weeks of struggling with this process, Sue expressed her frustration:

"[My HE group is] *spending a lot of time figuring out how can this* [HE project] *be co-created?...*[I know] *the* [peer] *conversations we're having are important. I'm just tired of 10 hours of talking about this* [topic] *a week* [and not coming up with any answers]*. The tricky thing is now that our group has been thinking about it, there is no right answer…it's just feeling out, "Okay, yeah, that seems like we're being ethical, and we're considering all these things," and I don't know how to deal with that* [ambiguity].

The program's lack of established processes for external engagement and normalized absence of partner communities in these discussions left Sue realizing they had never actually asked their partner community how they wanted to co-create the project. Sue found herself unable to progress without guidance or resources to access more knowledgeable expertise. She reflected, *"There are no processes in place that* [say]*, 'Okay, good, you're doing* [co-creation] *now'...Instead, it's just feeling out, 'Okay, that seems like we're being ethical'...and I don't know how to deal with that* [ambiguity]*."* After spending hours attempting to self-define co-creation, Sue's motivation for this

social justice goal declined due to the lack of tangible outcomes and the external pressure to complete her experiential assignment.

HE curricula normalized an insular approach to comprehending social oppression and justice, primarily through self-reflection and peer discussion. Course assignments directed students toward internal processing through class debates, online discussion boards, and reflective writing assignments, rather than engaging with external expertise. While reflection played an important role in learning, its use in isolation reinforced a problematic behavior: students, faculty, and peers defaulting to defining complex concepts like white saviorism, equity-oriented practices, anti-racism, and decolonization without drawing on established scholarship or the perspectives of impacted communities.

This behavior extended into students' HE work experiences. Sarah, a white US American student who interned at an HE organization training short-term volunteers from the United States, exemplified this dynamic when grappling with uncertainty about whether she was perpetuating white saviorism in her work:

> *I still sometimes feel like I am* [conducting white saviorism]*...Maybe I still am unintentionally. I don't think I'll ever know the answer to that…*[While] *a lot of* [the emotional beliefs] *for* [these groups] *probably involves the white savior complex…hopefully, in the future,* [these volunteers] *will continue to want to help* [marginalized communities].

Without engaging with diverse outside perspectives, including established scholarship scholars, such as Teju Cole's (2012) critique of white saviorism, which emphasizes prioritizing emotional

experiences over tangible social justice outcomes, Sarah could only vaguely speculate about its presence within her organization.

Behavior that Facilitates Student Resistance to Systemic Inequality

This research identified three key behaviors that empowered HE graduate students to identify and resist oppressive systems and sustain a commitment to social justice, as detailed in Table 5.

Table 3-5 Key Behavior Facilitating Resistance to Systemic Inequality

Behaviors	**Example**
Integrating relevant experiences of living with infrastructure disparities and social inequality—whether one's own or shared by others—to inform engineering decisions and approaches	*I had… a mentor… from the global south… and he really encouraged me to think critically about development approaches… I think his perspective has always really grounded mine.*
Using multidisciplinary perspectives on social good and ethics, particularly those rooted in marginalized communities' experiences, to analyze and improve HE practices	*I sought out electives that gave me different perspectives... a knowledge and injustice course and a class about black trans futures... The more you learn, the more you re-evaluate your beliefs.*
Learning about the systemic roots of infrastructure and technology inequality and the role of professions like international development and engineering in perpetuating disparities, to identify and	*The U.S. abolished Aboriginal land titles in Alaska... since* [then] *a lot of* [Indigenous] *people moved away because they needed to get higher-paying jobs, especially to pay*

oppose similar inequities in engineering decisions	*for their energy bills … A solar array would help them regain self-sufficiency.*

Relevant Experiential Knowledge of Marginalization

The first nurturing behavior we observed was students integrating experiential knowledge of marginalization into their HE approaches and aspirations. For example, through her university program, Meghan, a white US-American student, developed meaningful friendships with engineers from low—and middle-income countries. She was able to partake in in-depth, non-extractive conversations about the ongoing efforts to address insufficient infrastructure services in their communities.

> *My friends...*[would] *talk about the…work they wanted to do in their own countries and* [the influence of] *politics in infrastructure and why* [local engineering organizations] *struggled to improve infrastructure…I saw firsthand how important local perspective was in development work*

Meghan demonstrated a growing critique of the dominant deficit narrative she had internalized: that marginalized countries have insufficient infrastructure due to lacking engineering expertise. By integrating her friends' firsthand accounts of structural barriers faced by engineers from marginalized countries, she developed a broader understanding of infrastructure challenges, including local and global politics and the influence of outside nonprofits. This fueled her conviction that engineers from marginalized communities must be integrated within HE efforts, further motivating her pursuit of social justice. She began critiquing HE projects at her university that did not prioritize local perspectives and sought experientials aligned with these values.

Our research found that HE program structures facilitated students' connections to firsthand narratives of infrastructure disparities and marginalization. These experiences emerged through multiple channels: casual conversations with classmates who had lived through infrastructure challenges, structured classroom discussions about marginalization, and interactions with colleagues who shared their communities' struggles during HE internships. The curriculum and program norms sometimes emphasized learning from these lived experiences through assigned readings and memoirs from marginalized communities and social media accounts documenting infrastructure inequities. These stories of systemic barriers came from various sources. Some students learned from faculty and mentors who helped students partake in various critical reflections and learn from their own lived experiences of marginalization. In contrast, others integrated their own family members' experiences with infrastructure challenges into coursework and discussions.

Students also applied this behavior to nurture their resistance to harmful engineering practices when working independently in internships and making career decisions. For instance, Joshua, a student of color and US nationality, was engaged in an internship, implementing a water treatment project near his hometown, a community with which he had cultural, racial, and familial ties. He relied on his personal experience and what he learned from his community and family during a water pollution crisis during childhood to critically evaluate his internship's project mission:

> *There were a lot of engineers who made the problem worse by making false claims* [about how to clean my community's water]. *The problem was never access to technology…The problem is corruption* [and] *inequalities at the government level*

Joshua used his firsthand experience with poor water infrastructure to identify the limitations of technical solutions proposed by his internship, which ignored the socio-political structures perpetuating the communities' disparities. He also used these experiences to remain deeply motivated to abstain from these harmful band-aid solutions in his internship.

> *I had a crisis in engineering ethics…*[My company] *was going into public* schools [near my hometown] *and installing UV water treatment systems…*[However, it] *wasn't actually helpful because it wasn't addressing the* [underlying infrastructure] *problem, which is lead pipes. So* [the water is still] *not going to be safe.*

Joshua then leveraged his experiential knowledge of marginalization and structural oppression as motivation to pursue a career in opposition to the harmful engineering processes he identified. Specifically, He pursued a career path informed by a critical understanding of *"point-of-use"* engineering solutions that ignore the causes of pollution and inequitably only address water pollution at single spigots.

> *That was the last turning point for me from working in point-of-use water treatment in the US. I told the company I was not going to work with them…I knew I wanted to go to the municipal side* [of water treatment] *where we actually have control over* [improving] *the source water quality,* [and what is being] *provided to schools.*

Understanding Social Justice Through Multidisciplinary and Diverse Perspectives

The second nurturing behavior we observed was students incorporating diverse disciplinary frameworks and perspectives—particularly those grounded in marginalized communities' experiences—into understanding HE norms, policies, and practices and how they could improve. For example, Isabella, a non-indigenous student of color from a middle-income country who

aspired to work with Indigenous groups, took an Indigenous thought and theory course as one of her graduate school electives. She noticed a fundamental contradiction between how decolonization was conceptualized in her HE courses versus her Indigenous Studies course:

> *In my 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...*[from my Indigenous theory course, I learned] *that's already entirely backward because you're still assuming that humanitarian aid should be top-down.*

Through Indigenous Studies, Isabella recognized that HE spaces often approach decolonization superficially, focusing on gestures of power-sharing while ignoring the deeper power imbalances inherent in top-down aid models. She realized that even well-intentioned discussions of social justice can perpetuate inequality when they fail to center marginalized perspectives and address root structures of oppression. Rather than becoming disillusioned with these contradictions, her multidisciplinary education provided tools to advocate for implementing decolonization as defined by Indigenous scholars. She explained this vision: *'Indigenous studies* [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?'* This understanding enhanced her critique of social oppression in HE and her motivation to advocate for meaningful structural changes.

HE program structures supported this behavior through curricular design and encouragement from faculty and peers to pursue multidisciplinary coursework and engage with diverse authors. Students took courses across multiple fields, including moral philosophy, critical theories, women and gender studies, queer studies, education policy, anthropology, ethical/decolonial research

methods, environmental ethics, business ethics, and various ethnic studies such as African American Studies. Students reflected on finding valuable tools to inform their engineering projects and decisions from these courses: case studies of successful interventions, social justice frameworks and vocabulary, and examples of best practices. Students actively integrated these insights to strengthen their critique of existing practices and their motivation to create positive change.

Students also utilized their multidisciplinary education challenge and improved practices in HE projects when they had more independence, such as dissertations. For instance, Ali, a first-generation U.S. citizen from a low-income country, began questioning research practices while conducting household interviews as a research assistant. During interviews about employment opportunities in a marginalized community, he confronted an uncomfortable reality: 'One of the households that we interviewed...his response to a lot of our questions was, "Nothing, nothing. We have nothing"... It really makes you think this person…stands nothing to benefit from [this research].'

Ali demonstrated seeds of resistance by reflecting on how humanitarian-minded research could be exploitative, using community time and emotional energy to advance researchers' careers and knowledge production while failing to provide tangible benefits to the marginalized community members themselves. These seeds of resistance were nurtured through his anthropology coursework on 'extractive research,' which provided him with the vocabulary and theoretical framework to articulate his concerns and envision alternatives. Further, he utilized this newfound vocabulary to participate in more equitable research practices in his dissertation.

> *I am wary of being an extractive researcher… I'll even pay* [my community partners] *out of pocket for* [their data collection efforts] *because…I want to make sure that what they gain* [from this research] *is not just me sharing my results with them, because the results are theirs as well.*

Ali proactively challenged extractive practices by financially compensating his community partners for their time and contributions. While financial compensation alone could not eliminate all extractive dynamics, his exposure to multidisciplinary frameworks empowered him to challenge traditional research hierarchies and use personal resources to experiment with more equitable approaches despite lacking institutional funding. His experience shows how students can translate internal dialogues of concern into concrete attempts to resist harmful engineering practices.

Historical Education on Oppressive Structures

The final nurturing behavior we observed was students learning how norms, policies, and cultures in international development and engineering have historically reinforced inequality and leveraging this knowledge to challenge similar structures in their work and the greater HE field. For instance, David, a student of color from a middle-income country, encountered a critical perspective on infrastructure and economic disparities through coursework examining how global loans and debt perpetuate inequality. This perspective helped him challenge the deficit narratives familiar in his home country, including those he had at times internalized:

> *Some conversations that we have in* [my country in Africa, are]*, "Why are things in our country* [not] *working? Why is there so much corruption?"…and some people actually feel, "Whites are just smart people, we are not that smart…and that's why we*

> *haven't developed so much."* [However] *reading books like Divide…gives me a different perspective...There is…more that's going on…* [and] *It's important to understand the* [causes of] *the problem* [corruption and poverty] *so you know how to tackle it.*

Through historical analysis, David recognized how systemic factors—not an inherent lack of ability—have shaped economic and infrastructure disparities. This understanding enabled him to challenge oppressive narratives that blame marginalized communities for their circumstances while absolving dominant groups of their historical and ongoing role in maintaining global inequities. He applied this historical perspective to contemporary debates in his home country, particularly to reflect on alternative development pathways regarding international financial policies:

> *We have a debate going on in my country…*[on whether to] *go to one of the* [global loaning] *organizations. I know now… there are requirements for getting* [international] *loans* [that] *are not beneficial to the country…we would have to sell off some assets…Overall* [my courses] *gave me a lot to think about* [and] *give me different perspectives on developmental issues and power relations.*

David's case illustrates how historical education can empower students to critically analyze and resist inequitable policies in real-world engineering and development decisions.

Aspects of HE curricula nurtured students by exposing them to historical analyses and narratives of systemic inequality. Specifically, coursework examined how institutions—such as international development organizations, global financial systems, and engineering firms—have used mechanisms like global debt and loan conditions, extractive economic models, the lasting

repercussions of colonialism, and exploitative manufacturing systems to perpetuate infrastructure disparities. Students also explored how cultural and normative racism, classism, sexism, environmental destruction caused by industrial projects, and inequitable trade policies sustain global inequality. They engaged with these topics through literature, including *The Open Veins of Latin America, Killing the Black Body, Pedagogy of the Oppressed,* and *Confessions of an Economic Hit Man,* deepening their awareness of the structural forces shaping Humanitarian Engineering.

Students applied this behavior to engage with systemic inequality in HE projects where they had independence and agency. Diego, a student of color from the U.S., engaged in an HE project in a region with which he had some cultural and racial ties. Through his coursework, he learned one mechanism in which engineering projects have historically reinforced marginalization.

> *Engineering or international development projects in the past have contributed to reinforced globalization, which has increased poor countries' dependence on larger countries, even though it's under the guise of trying to do something productive...So that large-scale picture made me really start to think critically about how I wanted to be involved* [in engineering].

Diego's coursework enabled him to see how engineering could perpetuate dependency and exploitation through supply chains, resource extraction, and processing. This awareness fueled his desire to create engineering projects that fostered local autonomy and challenged systemic inequities. Specifically, he developed his thesis around the recognition that a locally-owned material processing plant could disrupt the oppressive relationship between wealthy corporations

and local miners in his partner community, shifting economic power back into the hands of the community.

Discussion and Implications

Reconceptualizing Transformational Resistance: New Insights from Humanitarian Engineering Education

This research revealed how Humanitarian Engineering (HE) education influences students in developing transformative behaviors in response to systemic inequality. During coursework, internships, and projects, students encounter various engineering structures that harm or exploit marginalized communities, sometimes recognizing these inequalities and considering whether to challenge them. Whether students move beyond this initial recognition to actively resist these inequitable structures is influenced by their educational environment. Specifically various educational program structures—including institutional missions, cultural norms, formal policies, and curriculum design— motivate students to comply with existing systems or empower them to develop transformative resistance behaviors.

These findings are particularly significant given our sample of students who specifically chose HE programs, motivated by engineering's potential for social impact. That these practices hindering resistance persist even in programs explicitly focused on social justice suggest that they stem from deeper colonial and neoliberal norms embedded throughout engineering education. By analyzing how these practices manifest in HE spaces - where students and faculty actively work to challenge systemic inequality – we gain insight into how engineering education's historical structures continue to shape approaches to social justice.

This discussion section examines how these identified behaviors and influential underlying educational institutional structures build upon existing scholarship in transformational resistance and engineering education.

Behavioral Patterns in Resistance Development

Our findings revealed that HE students' engagement with and resistance to inequitable structures was limited by three key behaviors: (1) prioritizing individual and institutional goals over community wellbeing when faced with academic or career pressures, (2) maintaining emotional and practical distance from their work's impact on partner communities, and (3) relying on insular understanding of inequality and social justice rather than engaging with external expertise or marginalized perspectives.

As students exhibited these behaviors within HE programs and in subsequent work experiences, they reported anxiety about challenging established practices and deliverables, expressed frustration and resignation about their critical perspectives, and developed limited views of their roles and responsibilities toward partner communities. Further, they missed opportunities to build a deeper understanding of systemic inequality through exposure to diverse perspectives and practices for engaging with authority. Many of these patterns align with prior TRF research showing students becoming disengaged when their critiques of social oppression lack adequate support. As Solórzano & Bernal (2001) found, when students lack the tools to develop motivation for social justice or disrupt the structures they critique, they often experience frustration, apathy, or resignation, leading to disengagement.

However, our findings reveal an important distinction from previous TRF scholarship, which primarily examined marginalized students resisting structures directly harming them. The three

hindering behaviors often involved students deferring to individuals unaffected by their engineering projects to understand whether their practices were harmful to marginalized communities. James deferred to internal dialogues and leadership instructions to assume that the potential future benefits of the portable database he was developing would outweigh its immediate adverse effects on the teachers and students who received an early iteration of it. Julia justified visiting her partner community during COVID-19 as necessary for project advancement. Nicole narrowed her definition of an engineer's role to exclude monitoring long-term impact and resiliency, assuming this limitation of scope gave communities more autonomy. Sue and Catherine relied on personal and peer intuition to evaluate whether their HE projects approach involved harmful top-down practices and white saviorism, assuming their personal reflections and group discussions could adequately identify harmful power dynamics without direct community input.

This distinction—where socially privileged individuals struggled to defer to those directly affected by engineering projects when assessing potential harm—helps us understand how social privilege influences students' development of transformational resistance, as it bridges broader scholarship on how privilege shapes one's worldview. Social dominance inherently limits one's ability to fully comprehend the oppression over which they hold dominance. For instance, whiteness fundamentally constrains one's capacity to accurately understand the current state of racial oppression (Allen, 2001). Frye's (1983) birdcage analogy describes how socially dominant individuals can observe some aspects of oppression like individual "wires" of a birdcage; however, unless you are the community experiencing oppression, it is impossible to understand the complete system of confinement—the cage itself that prevents escape from an oppressive environment. Indeed, research shows that when attempting to understand social justice, individuals from privileged backgrounds often become confused and contradictory about equality, such as white

teachers trying to assume the experiences of their students of color (Bonilla-Silva & Embrick, 2006; Matias et al., 2014). Moreover, modern society socializes individuals to see their limited perspectives as adequate for understanding oppression (Sensoy & DiAngelo, 2017), further exacerbating the confusion and frustration students experience when relying on their own and other outsiders' limited perspectives on the hardships their partner communities face.

This analysis reveals a potential challenge in HE students' resistance development: their social privilege may create barriers to meaningfully learn from and defer to those directly affected by engineering projects, illuminating an additional complexity when students attempt to resist systems where they hold positions of dominance.

Program Structures as Mediators of Resistance

Our research also illustrated the influence of HE program structures—including missions, norms, policies, and curriculum—on whether students challenged or complied with oppressive engineering practices. Some structures identified in our findings included, but were not limited to: funding mechanisms tied to institutional deliverables, project timelines, communication protocols with partner communities, course assignments emphasizing peer discussion, faculty mentoring approaches, evaluation metrics focused on academic outputs, predetermined project scopes, and research requirements prioritizing publication.

These structures persuaded students through multiple mechanisms: trapping them with institutional pressures, overwhelming them with unsupported emotional distress, exhausting them when attempting to advocate for change, confusing them about relying on their own intuition for social justice decisions, convincing them to rationalize compliance, and leaving them feeling powerless to change engineering practices. The influence of structures on students' oppositional

behavior aligns with prior TRF scholarship that shows students encountering professional and social barriers to resisting structural oppression. For instance, students of color face additional educational barriers when they demonstrate resistance behaviors, such as receiving detention, being negatively labeled as "misbehaving," and experiencing pressure to show compliance by suppressing their authentic expression (Annamma et al., 2016; Milner, 2013; Noguera, 2003).

However, these students' relationship with institutional structures differs fundamentally from traditional TRF contexts that show structures actively excluding marginalized communities from educational spaces and punishing their opposition to this exclusion. For instance, when black students speak out about the culturally unresponsive curriculum and the absence of African American studies, structures like dismissing their concerns as "disruptive" or stereotyping them as "troublemakers" further silences the african american perspective from education. Or students who express outrage against the disproportionate rates of dropout and pushout affecting students of color in their school may face suspension and detention, putting them on the same track of systemic exclusion they are trying to resist.

In contrast, the structures in HE programs may persuade students to not include marginalized communities' voices. For instance, Sue encountered program structures - including course assignments focused on peer reflection and a lack of established processes for community engagement - that encouraged her team's development of co-creation approaches without input from their partner community. Multiple institutional pressures - including funding tied to program completion, faculty influence, and preset project timelines - motivated James to prioritize institutional goals over community input in his project's mission and implementation. Similarly, hierarchical project structures and institutional emphasis on travel schedules motivated Julia to separate community health impacts from her team's decision-making about future site visits.

This distinction—where HE students are persuaded to become active participants in excluding marginalized communities—bridges TRF scholarship with critical studies on structures that uphold social dominance. Harris' (1993) framework of 'whiteness as property' illuminates how policies, cultural norms, and institutional practices enable socially dominant groups to maintain their privileges while claiming "passivity" and avoiding accountability. Social privileges, like whiteness, function legally as property rights—similar to land titles or intellectual property. Structures like property laws, zoning regulations, and trespassing ordinances entitle landowners to use their land without concern for others' benefit, exclude whomever they desire, maintain a reputation of "good" intentions despite using land for personal benefit, and pass these rights to their heirs. Furthermore, structures like neighborhood watch programs frame surveillance as "community safety." Meanwhile zoning board policies that treat landowners as neighborhood experts and property tax-based school funding that ties community resources to property values feed narratives that landowners know what's best for a neighborhood and deserve greater decision-making power.

Whiteness operates similarly to a property right, where social norms and policies persuade white people to 1) use and enjoy their whiteness and associated privileges, 2) maintain an elevated reputation while doing so, 3) exclude others from accessing these privileges, and 4) pass these advantages to their heirs. Scholars have shown how other forms of social dominance, like citizenship status and class privilege, operate through similar property-like entitlements. We see students in this study navigating similar structures reaffirming their "property rights"—the privileged positions they hold in their HE projects. Social norms and school policies persuade them that they are entitled to create HE mission statements and project goals that align with their institutional interests—such as career advancement and innovation—for their own "use and

enjoyment,"; exclude marginalized communities from creating these goals and defining practices like co-creation; and maintain their reputation as socially-minded humanitarian professionals despite exercising these exclusionary rights.

In sum, this distinction in how structures operate—where traditional TRF shows structures directly punishing marginalized students' resistance through further excluding their voices, dignity, and educational attainment in schools, while HE structures instead persuade privileged students to participate in excluding others—helps bridge TRF scholarship with critical theories about how institutions protect social dominance, advancing our understanding of how educational structures influence students' resistance to systems where they hold positions of privilege.

Practical Contributions

Our findings reveal specific ways HE programs can consider reshaping their institutional structures to better support students in developing meaningful resistance to the inequitable structures they encounter and learn about. Furthermore, by bridging TRF scholarship with critical studies on social dominance, we provide insights into how educational programs can support students in resisting systems where they hold positions of privilege.

The behaviors we observed helping students develop meaningful resistance included integrating relevant experiences of living with infrastructure disparities - whether their own or those shared by others - to inform their engineering decisions; using multidisciplinary perspectives on social good, particularly those rooted in marginalized communities' experiences, to analyze and improve HE practices; and learning about the systemic roots of infrastructure inequality and engineering's historical role in perpetuating disparities to identify and oppose similar patterns in current engineering decisions. For instance, students like Joshua drew on firsthand experiences with water

infrastructure challenges to critique superficial technical solutions. At the same time, Isabella used Indigenous studies frameworks to recognize how traditional HE approaches can perpetuate colonial power dynamics. David applied a historical understanding of global debt systems to challenge deficit narratives about infrastructure disparities in his home country.

Across these three behaviors, a crucial commonality emerges: students attempting to resist systems where they held positions of privilege needed to draw upon voices and expertise beyond traditional engineering authorities—moving past individual reflection, peer discussions, and deference to engineering expertise and leadership to develop and sustain resistance effectively. Whether through peers sharing lived experiences of infrastructure disparities, interdisciplinary scholars offering critical frameworks, or historical accounts documenting systemic oppression, students strengthened their capacity to critique social oppression and maintain motivation for social justice by engaging beyond their individual perspectives.

This finding builds on Leydens and Lucena's (2009) work on intentional listening practices in HE, as well as research showing how experiences with inequity and social suffering shape both students' understanding of justice and their aspirations to reduce inequities in their careers (Naphan-Kingery et al., 2019; Reynante, 2022). The potential impact of this approach supports existing HE programs that utilize multidisciplinary social and environmental science curricula and elective opportunities (Nock et al., 2024; Vargas-Ordóñez & Hynes, 2020), as demonstrated by students like Isabella, who drew on Indigenous studies coursework to critique colonial dynamics in humanitarian aid.

The importance of students' privileged positions in shaping how they engaged with systemic inequality further illuminates why drawing from broader communities - including disciplinary

experts and community members - was crucial for developing both an understanding of social oppression and motivation for social justice. This aligns with Critical Race Theory, which emphasizes that lived experiences of oppression provide the most complete and nuanced understanding of systemic inequality, using tools like counter-storytelling to capture these experiences in research (Delgado & Stefancic, 2017; Hubain et al., 2016). CRT scholars also stress the importance of interdisciplinary perspectives, drawing from feminist, Latinx, and disability studies to better understand how various forms of oppression intersect and manifest. Hooks (1996, p. 20) further emphasizes the value of these diverse perspectives, arguing, 'A renewed, organized black liberation struggle cannot happen if we remain unable to tap collective rage.' She highlights that embedded in the Black experience is both the terror of witnessing racism and a deep yearning for social justice (Bell, 1992; hooks, 1995)—experiences less immediately accessible to HE students operating from positions of relative privilege. Consequently, understanding the current state of social oppression and maintaining motivation to address it can be better sustained when HE students intentionally expand the expertise they draw upon.

While this study identified program structures that enabled students to engage with diverse perspectives and marginalized communities—such as multidisciplinary electives, flexible project timelines, and community partnerships—these structures often operated as optional pathways rather than institutional requirements. Students had to navigate structures identified in part one of this findings section that motivated compliance with traditional engineering approaches while simultaneously investing additional time and effort to pursue these opportunities. For instance, Ali had to independently enroll in a critical research methodology course beyond his required engineering curriculum and use his personal funds to compensate community partners for their research contributions to try to resist exploitative research practices.

This tension reveals how 'property rights' of engineering privilege remain intact: Students can access alternative perspectives and develop critical career aspirations and strategies to improve engineering, but the power to define engineering practices, determine project goals, and evaluate success remains concentrated in traditional engineering authorities—often including themselves. This suggests that beyond creating access to diverse perspectives, HE programs must examine how their 'neutral' policies—from funding mechanisms to evaluation metrics—preserve existing power distributions. Programs should consider how they might transfer actual decision-making power to marginalized communities, for instance by requiring community co-creation of technical criteria or making community evaluation a central component of project assessment.

Moreover, this need for structural change, rather than relying on individual commitment, is supported by Bell's concept of 'interest convergence' (1980), demonstrating how advances in civil rights historically occurred only when they aligned with the interests of those in power. For instance, while school desegregation was achieved through Brown v. Board of Education when it served white interests in improving America's international image during the Cold War, particularly with newly independent nations of color, subsequent civil rights progress stalled when Black citizens' interests in areas like economic justice and housing equity diverged from white interests in maintaining economic and social advantages. When applied to Humanitarian Engineering, this framework helps explain why creating optional pathways for engaging with marginalized perspectives, while maintaining traditional power structures, has limited transformative potential. Even well-intentioned HE students, who often hold social dominance over partner communities through factors like nationality, education level, and race, may prioritize individual or institutional interests over community needs when these interests diverge.

In sum, meaningful transformation in HE programs requires examining and reforming the institutional structures that preserve engineering privilege. This means creating mechanisms that explicitly align student and university interests—like grades, career advancement, and program metrics—with genuine benefit to marginalized communities. Programs must move beyond simply providing access to alternative viewpoints toward actually transferring power to partner communities in defining, evaluating, and implementing engineering practices.

Limitations

It is essential to acknowledge the limitations of this study. Despite a substantial sample size, the study faced several demographic constraints. Most notably, it lacked diverse perspectives from US American students of color, and the undergraduate experience was outside this work's scope. The study also did not deeply examine how specific aspects of students' personal histories, cultural contexts, and lived experiences shaped their approaches to resistance. Future research should prioritize amplifying diverse voices to understand better how race and ethnicity intersect with HE experiences and the development of resistance. Finally, our sample size of students per program was insufficient for meaningful program-to-program comparisons; future research with larger program-specific samples could examine how program maturity and structure such as curriculum and focus influence student resistance development.

Temporal limitations were also present - while the study identified student behaviors and resistance patterns during their educational experience, it did not track how these manifested in their subsequent professional practice, leaving questions about these educational experiences' long-term impact. Finally, there were theoretical constraints to consider. The frameworks used in this study, particularly CRT, primarily focus on the structures of racism within the US. As such, their applicability to global contexts or beyond U.S.-centric perspectives may be limited. Future

research could consider exploring additional theoretical frameworks, such as feminist theory, postcolonial theory, or intersectionality, to expand the scope of analysis.

Conclusion

This study reveals how Humanitarian Engineering (HE) education shapes students' engagement with systemic inequality in complex and often contradictory ways. Our findings demonstrate how students encounter various engineering practices that can harm or exploit marginalized communities during their educational experiences. In these moments, educational program structures—including funding mechanisms, evaluation metrics, and project timelines—can motivate students toward behaviors that fuel compliance rather than resistance. These behaviors include rationalizing institutional priorities over community wellbeing, maintaining emotional and practical distance from project impacts, and relying on insular understanding rather than engaging with marginalized perspectives.

Nevertheless, our research also illuminates how educational structures can nurture students' capacity for transformative resistance. We found that when programs created opportunities for students to integrate lived experiences of infrastructure disparities, engage with multidisciplinary perspectives on social justice, and learn about the historical roots of engineering inequality, students developed stronger abilities to identify and challenge oppressive practices. Examining these dynamics through Critical Race Theory frameworks illustrated how educational environments can preserve existing power hierarchies or nurture meaningful resistance to systemic inequality.

This understanding suggests that transforming HE education requires examining how program structures shape student behaviors and engagement with systemic inequality. While creating

access to diverse perspectives is important, programs must also consider how their "neutral" policies—from funding mechanisms to evaluation metrics—preserve existing power distributions. By recognizing these dynamics, HE programs can work toward structural changes that better align their educational practices with their mission of cultivating engineers equipped to challenge systemic inequality.

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Chapter 4. Developing Social Justice Self-Efficacy in Humanitarian Engineering Graduate Education

Abstract

While humanitarian engineering (HE) programs increasingly emphasize preparing students to engage in social change—from addressing inequitable access to infrastructure and technology in marginalized communities to challenging biases in the workplace and examining norms in engineering organizations that perpetuate inequality—there remains limited understanding of how these experiences build students' confidence to engage in social justice activism. This study investigates how HE graduate education influences students' social justice self-efficacy (SJSE)—their perceived ability to create positive social change across personal, interpersonal, community, and institutional dimensions. Drawing from 88 interviews with 22 students across six HE graduate programs during their first year, we identify a distinct three-phase developmental pattern: (1) a critical exposure phase in fall term coursework that dramatically increased personal SJSE while often decreasing community and institutional dimensions; (2) an integration phase in spring term experiences where students developed more balanced SJSE by identifying specific approaches to social impact while maintaining critical awareness; and (3) a testing phase during summer fieldwork where students confronted the challenges of applying their developing SJSE in real-world contexts. Rather than developing uniformly, students experienced non-linear, asymmetric growth across SJSE dimensions, often maintaining optimism in one area despite challenges in others. These findings suggest HE education can effectively prepare students for social justice advocacy when programs provide targeted support during these critical transitions, encourage context-specific engagement rather than system-wide transformation, create opportunities for social justice advocacy practice, and develop students' interpersonal SJSE alongside other

dimensions. This research advances understanding of how HE programs can foster advocates for making engineering more equitable, inclusive, and responsive to marginalized communities' needs.

Introduction

Humanitarian Engineering (HE) programs train students to improve technologies, infrastructure, and public service delivery in marginalized communities. Given their focus on working with marginalized communities, these programs simultaneously emphasize preparing students to engage in social justice activism (Burleson et al., 2023a). Social justice activism promotes social change toward equitable access to resources, opportunities, and liberties for all while empowering marginalized groups (Chapman, 2013). This commitment to social justice manifests in evolving professional expectations. HE practitioners are increasingly called upon to examine how biased assumptions affect their work and use their professional influence to make policies in their engineering organizations more equitable (Peace Direct et al., 2021).

To understand students' growth towards engaging in these practices, we need to examine how HE education influences students' self-efficacy to engage in social justice activism. Self-efficacy, a strong belief in one's capabilities (Bandura, 1997), is a critical predictor of engineering students' persistence, achievement, and career development (Lent et al., 2005, 2007). Existing literature suggests a correlation between HE educational experiences and increased social consciousness in engineers (Budny & Gradoville, 2011; Litchfield & Javernick-Will, 2015), and HE students demonstrate strong technical and professional self-efficacy (Litchfield et al., 2016). However, given that social justice self-efficacy has been correlated with students' interest and commitment to social justice activism in their careers (M. J. Miller et al., 2009), research is needed to investigate students' social justice self-efficacy specifically.

This study addresses this gap by investigating how different learning environments contribute to students' SJSE development. Drawing from 88 interviews with 22 students across six HE graduate programs, we track changes in students' perceived ability to engage in social justice activism across four spheres of influence. Building on Miller et al.'s (2009) framework, we examine SJSE development across four key spheres: 1) recognizing and challenging their own biases, 2) challenging others' biases, 3) addressing inequities by improving conditions within communities, and 4) influencing policy, culture, or norms of larger institutions to be more just. By examining these spheres, this research advances our understanding of how HE programs can effectively develop students' SJSE to foster advocates for making the engineering field more equitable, inclusive, and responsive to the needs of marginalized communities.

Literature review

Humanitarian Engineering Graduate Education

Since the Colorado School of Mines established the first HE minor in 2002, the field has grown substantially, with 67 HE programs and initiatives operating across the United States by 2020 (CSM, 2020; EWB, 2021; Smith et al., 2020). These programs train engineers to work in partnership with marginalized communities to address their infrastructure and technology needs. Graduates of HE programs often aim to work on modern engineering challenges outlined in frameworks like the United Nations Sustainable Development Goals, whether in large international development organizations, small grassroots non-profits, or traditional consulting engineering firms.

Throughout these workspaces, HE graduates must advocate for increased justice, whether in terms of how marginalized communities are thought about, talked about, represented in policies and norms, and affected by the engineering industry. Many traditional approaches to infrastructure

implementation in marginalized communities have undermined their agency and control over their development (Lucena et al., 2010), created dependency between countries, distorted local economies (Hickel, 2018), and resulted in short-term, culturally irrelevant "band-aid" solutions to inequality (Peace Direct et al., 2021; Sachs, 2019). Additionally, policies and norms in conventional engineering firms have led to project outcomes that inadvertently exacerbate inequitable access to technology and infrastructure services (Costanza-Chock, 2020; Yates & Murphy, 2019). As a result, HE practitioners are increasingly called upon to engage in workplace social justice activities, including examining their own biases and challenging discriminatory language and assumptions among colleagues (Peace Direct et al., 2021) and to change policies, culture, and norms as the international aid industry implements anti-racist practices (Ali, 2020; New York Times, 2021).

While research on how HE education develops students' capacity for social justice work remains limited, studies suggest these programs can positively influence students' social motivation and concern. Professionals and students involved in the HE organization Engineers Without Borders (EWB) were more motivated to pursue engineering for social good than non-members (Litchfield & Javernick-Will, 2015). Further, HE students have demonstrated a greater willingness to sacrifice higher salaries for socially impactful careers than their peers (Budny & Gradoville, 2011). Finally, engineers who received training on their responsibility to public welfare, a common component of HE education, showed a greater understanding of their role in protecting public health and safety and recognizing the social and ethical dimensions of their work (Cech, 2014).

However, without studies specifically examining this development in students, questions remain about the effectiveness of HE education in building these skills. Some scholars have questioned whether instruction on engineering's social context and impacts, common aspects of HE

coursework, is sufficient in empowering students to critically examine structures of privilege and marginalization (Niles et al., 2020). Others argue that this instruction inadequately helps students analyze how broader systems like neocolonial power, imperialism, and white supremacy shape engineering practice (Nieusma & Riley, 2010).

In summary, in order to help students translate their social motivations into practical action, scholarship is needed to examine how HE education develops students' capacity for social justice activism.

Social Justice Self-Efficacy

Self-efficacy, defined as one's belief in one's ability to successfully perform specific tasks or behaviors, is an established predictor of students' capacity and motivation to engage in various activities after graduation. This concept has been a critical predictor of engineering students' persistence, achievement, and career development (Lent et al., 2005, 2007). Research has shown that self-efficacy has a strong connection to career goals and actions, as individuals with high self-efficacy are more likely to set ambitious career goals, persist through challenges, actively seek opportunities, and take concrete steps toward achieving their desired career path. A strong belief in their capabilities drives them to pursue and achieve their career aspirations (Bandura, 1997).

Building on this understanding of self-efficacy's importance, social justice self-efficacy (SJSE) provides a validated framework for measuring how students develop confidence in their ability to advance social justice through their careers (M. J. Miller et al., 2009). Research has shown that increased SJSE correlates with college students' enhanced social justice interest and commitment (M. J. Miller et al., 2009) and increased commitment to advocacy for others in their careers (Van Voorhis & Hostetter, 2006).

Social justice self-efficacy is defined by and broken into students' confidence across four distinct yet interconnected domains, originally synthesized from various ecological social justice frameworks (M. J. Miller et al., 2009; Bronfenbrenner, 1977; Neville & Mobley, 2001; Vera & Speight, 2003). These domains include personal, interpersonal, community, and institutional SJSE. Personal SJSE refers to a student's perceived ability to examine their own worldview, biases, and prejudicial attitudes after witnessing or hearing about social injustice. Interpersonal SJSE encompasses a student's perceived ability to challenge others' perspectives, biases, and prejudicial attitudes, including those related to racial, ethnic, and religious intolerance. Community SJSE addresses a student's perceived ability to support efforts that reduce inequitable access to resources, opportunities, and liberties in specific communities. Finally, institutional SJSE reflects a student's perceived ability to influence change within institutions and systems by dismantling and reforming the norms, cultures, and policies perpetuating injustice (Miller et al., 2009). A visual representation can be found below in in Figure 1

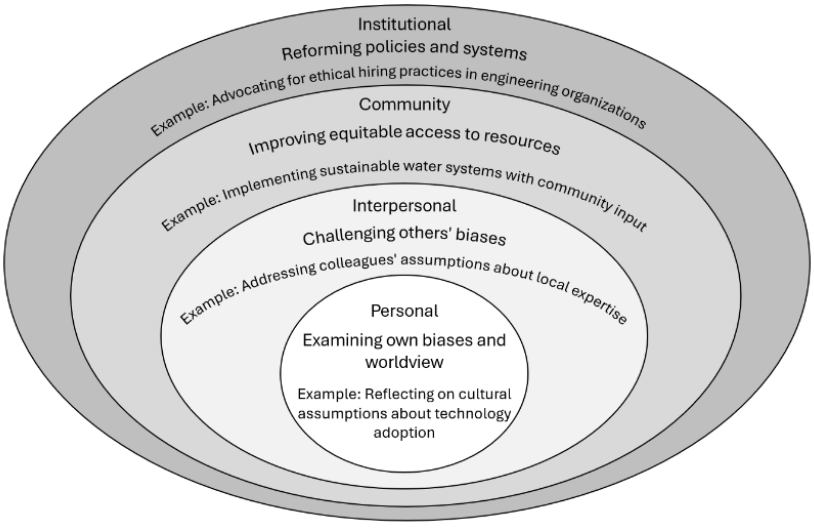

Figure 4-1 Social Justice Self-Efficacy Framework

While research has established the importance of self-efficacy in engineering education, there needs to be more investigation into how different HE learning experiences influence students' SJSE

development. Studies have shown that engineers involved with the HE club, Engineers Without Borders (EWB), demonstrate equal technical self-efficacy to their peers and increased self-efficacy in professional skills like multidisciplinary teamwork, communication, and understanding professional and ethical responsibilities. (Litchfield et al., 2016), which could indicate increased SJSE in any of the four domains because these professional competencies align closely with social justice work. For instance, effective communication enables challenging biases, teamwork indicates skills for collaboratively improving community resources, and ethical responsibility awareness suggests a capacity for recognizing personal biases and driving institutional change. At the same time, HE students have expressed doubt about their ability to serve communities where they lack cultural, linguistic, or geographic connections, and question their capacity to advocate for equitable practices within engineering corporations (Stine et al., 2024; Stine, Javernick-Will, Tanksley, et al., 2023). Moreover, when confronting complex ethical dilemmas related to addressing community inequities or reforming organizational policies, HE-oriented students have reported feeling frustrated and disengaged (Niles et al., 2018).

While humanitarian engineering education remains understudied and engineering in general has a dearth of research on how educational experiences influence SJSE development, other disciplines offer valuable insights. Research in environmental education found that environmental justice self-efficacy increased when students personally identified with issues, had access to quantitative data, recognized collaboration's importance, and understood clear definitions of environmental justice, though efficacy decreased when faced with complex problems and limited educational exposure (Kooi, 2023). Similarly, vocational psychology research revealed that collectivism—where the self is experienced as part of a larger group—and a sense of calling—characterized by an internal

or external summons to meaningful prosocial work—were significant predictors of SJSE development (Autin et al., 2017).

Despite the lack of research on the influence of HE education on student development, scholars have identified common program elements within HE programs. The limited scholarship on HE educational approaches shows that coursework typically includes both standard core classes providing breadth in HE work and specialized electives (Smith et al., 2020). For example, Berkeley's Development Engineering program offers a broad base of core courses in design, evidence-based assessment techniques, economic development, community engagement, ethics, and systems thinking alongside four concentration areas (Thomas et al., 2021). Beyond coursework, programs frequently incorporate project-based learning where students participate in research or service-learning during the semester, often working with marginalized communities as collaborators (Smith et al., 2020; Thomas et al., 2021). Many programs also include fieldwork and internship components, where students travel to marginalized communities to collect data and implement infrastructure or work under organizations on HE-related issues. For instance, CU Boulder requires a field practicum that embeds students with professional organizations for six weeks to six months to gain hands-on experience working with community partners (Thomas et al., 2021).

Drawing on these insights about common elements of HE education and the impact of SJSE on student career pathways, this study investigates how different learning environments contribute to students' SJSE development. **Specifically, we ask: How do coursework, project-based learning, and fieldwork experiences influence the development of personal, interpersonal, community, and institutional social justice self-efficacy in humanitarian engineering graduate students**

during their first year of education? Understanding these relationships can inform the design of more effective educational interventions that prepare engineers to be social justice advocates.

Methods

Data Collection

To investigate the educational development of HE students, this study examined six graduate programs in the United States offering degrees in humanitarian engineering (HE). Programs were selected from 45 HE-affiliated education programs (Pieffer, 2020), focusing on those with complete graduate degrees, available faculty feedback, and similar missions of educating engineers for "collaborative, just, socially responsible, and sustainable" solutions (CSM, 2020).

Participants were initially recruited for a larger study on HE graduate education through email advertisements distributed by program directors and professors. For this specific study, we focused on 22 students (2-8 per program) who began their programs in Fall 2021 and completed all four interviews over three terms (Fall 2021, Winter 2022, Summer 2022, and Fall 2022). This selection criterion enabled more precise tracking of the impact of specific learning experiences across participants' early graduate school journey. We provided a $20 honorarium for each interview. Interviews were conducted virtually or face-to-face, depending on participant preference and location.

Our research team developed an interview protocol designed to probe students' fluctuations in SJSE. For broader context, we began interviews with open-ended questions discussing their expectations and experiences before inquiring about specific aspects of their educational experience related to social justice, including topics such as equity, marginalization, colonialism, power dynamics, or ethics. Here, we asked about the four dimensions of SJSE. To explore students'

personal SJSE, we probed for critical self-reflection and asked questions such as "Did any educational experiences align with or challenge your worldviews?" We examined students' interpersonal SJSE by asking questions like "Were there any times you heard someone talking about development in a way you thought was problematic?" followed by "What happened?" and "Describe your confidence standing up to someone you disagree with in development?" To understand students' community SJSE, we first broadly asked, "Please describe your confidence that you can make progress towards equality." We also inquired more specifically about their HE-related experiential work, asking, "How are you trying to make this work successful?" followed by probing questions about making their work "ethical, anti-racist, decolonized, have good power dynamics, or be appropriate to community context." Finally, to assess students' institutional SJSE, we asked questions such as "Are there ways that you feel institutions in sustainable development (NGOs, governments, engineering organizations) need to change?" and " What are the ways you feel you would have or not have the power to change these institutions?"

We obtained IRB approval (protocol #21-0207), transcribed interviews using Trint (Version 1.0.68, 2023), and coded data with NVivo (Version 14, 2024). Given the small size of HE programs and sensitive discussions about social justice, we implemented stringent confidentiality measures, including removing identifying details, using pseudonyms, and carefully selecting quotes that couldn't be traced to individuals or programs.

Data Analysis

To the use of social justice self-efficacy development to understand HE education, this research employed an abductive approach, combining deductive analysis of established SJSE constructs with inductive analysis of emerging patterns in the data. First, the four domains of SJSE—personal, interpersonal, community, and institutional—were adapted for the HE context by focusing on how

each form of activism related to improving access to essential services in marginalized communities. While Appendix B provides complete codebook definitions and examples, in sum these four SJSE domains manifest in students' confidence to critically examine their assumptions about marginalized communities and infrastructure inequity (personal), challenge biased perspectives among colleagues, authority figures and partner communities (interpersonal), implement infrastructure solutions that address inequities (community), and transform policies and practices within engineering organizations to better serve marginalized populations (institutional).

Student interviews were coded for increases and decreases in self-efficacy across these domains, resulting in eight primary codes (four domains × two directions of change). We coded increased self-efficacy when students expressed growing confidence in their ability to create social change within one of the four domains. For example, one student demonstrated increased Community SJSE when she stated: *"I like market system strengthening* [approach to HE] *because* [...] *It's a much more sustainable process."* Within the interview segment from which this quote came, the student illustrated increased self-efficacy as she reflected on why she believed this business development approach could effectively improve sanitation access in marginalized communities and reflected on growing confidence to implement this approach in her future career.

Conversely, we coded decreases in self-efficacy when students expressed struggles or setbacks in their confidence to improve social justice. These decreases manifested in different ways across domains: feeling overwhelmed by complexity and struggling to find learning resources (personal), doubting their ability to influence others (interpersonal), questioning the effectiveness of their approaches (community), or feeling powerless to change organizational policies and cultures. For instance, one student expressed decreased institutional self-efficacy when reflecting on struggling to implement a sustainable way to maintain a sanitation system at a school, feeling current policies

and norms were insurmountable, stating, *"The government says education is free, but then they don't give the schools enough money to run...*[and] *maintain* [facilities]. *And* [we] *are thinking of ways to put structures in place* [...] *to pay for* [the facilities]. *But then the government is saying education is free."* This student demonstrated decreased self-efficacy as they expressed powerlessness to change the ineffective norms and policies that provide funding systems for the facility they are implementing.

In addition to coding self-efficacy changes, we tracked when and where these changes occurred using temporal codes across students' first two academic terms (Fall 2021 and Spring 2022) and summer experiences (May-August 2022). Within each temporal period, we categorized experiences into three contexts: coursework (traditional classroom settings), project-based work (including research and thesis development), and fieldwork (extended experiences in communities or professional settings outside the university). These temporal and contextual categories were developed as they represent common HE pedagogical approaches (Smith et al., 2020) and showed distinct patterns of SJSE development during preliminary analysis.

To analyze these changes systematically, we created matrices tracking the frequency of SJSE increases and decreases across domains, learning contexts, and time periods. This approach revealed broad patterns in SJSE development, with each matrix cell indicating how many students expressed changed confidence in a specific domain-context-time combination (e.g., 21 students reporting increased personal SJSE during fall term coursework would count as 21 increases in that cell)

To provide a rich qualitative context for understanding the patterns in the quantitative matrix analysis, we conducted an in-depth qualitative analysis of six focal students (one from each

program) to illuminate how and why these self-efficacy shifts occurred. These focal students were selected to maintain diverse representation across demographic backgrounds, prior experiences, and programs. Detailed demographic information for these focal students is provided in table 1 below. For each focal student, we traced their longitudinal journey across all four interviews, analyzing coded SJSE segments chronologically to identify key transitions, catalysts for change, and connections between different SJSE domains.

Table 4-1 Interviewee Self-Identified Characteristics

Student	Gender	Background	Academic Background	Prior Experience
Teagan	Woman	Student of color with ties to a middle-income country	Engineering	Professional engineering work plus undergraduate HE projects
Nate	Man	White American	Other STEM	Multiple years of professional HE work
Gabby	Woman	White American	Engineering	Undergraduate HE coursework and projects
Lisa	Woman	White American	Engineering	Undergraduate HE coursework plus volunteer fieldwork
Remy	Man	Student of color with ties to middle-income country	Other STEM	HE volunteer fieldwork experience
Gordon	Man	Student of color with ties to middle-income country	Engineering	Extensive undergraduate HE fieldwork

Finally, to validate our interpretations, we shared preliminary findings with participants through ongoing conversations during interviews and a preliminary manuscript with the opportunity for them to provide feedback on our analysis. This member-checking process helped ensure our findings accurately reflected students' experiences across their graduate programs.

Findings

Patterns of SJSE Development

Our analysis identified patterns in how students' social justice self-efficacy evolved during their first year in humanitarian engineering graduate programs. Figures 2 and 3 present visual representations of these changes across the four SJSE domains during the Fall and Spring terms, as well as summer fieldwork experiences.

The data presented in these figures illustrates several critical observations: Fall term coursework dramatically increased personal SJSE while often decreasing community and institutional SJSE; Spring term experiences showed more positive development across domains with significant project-based increases in community SJSE; and summer fieldwork and project-based work served as intensive testing grounds where students experienced both significant gains and challenges in applying their SJSE in real-world contexts, particularly in institutional and community dimensions.

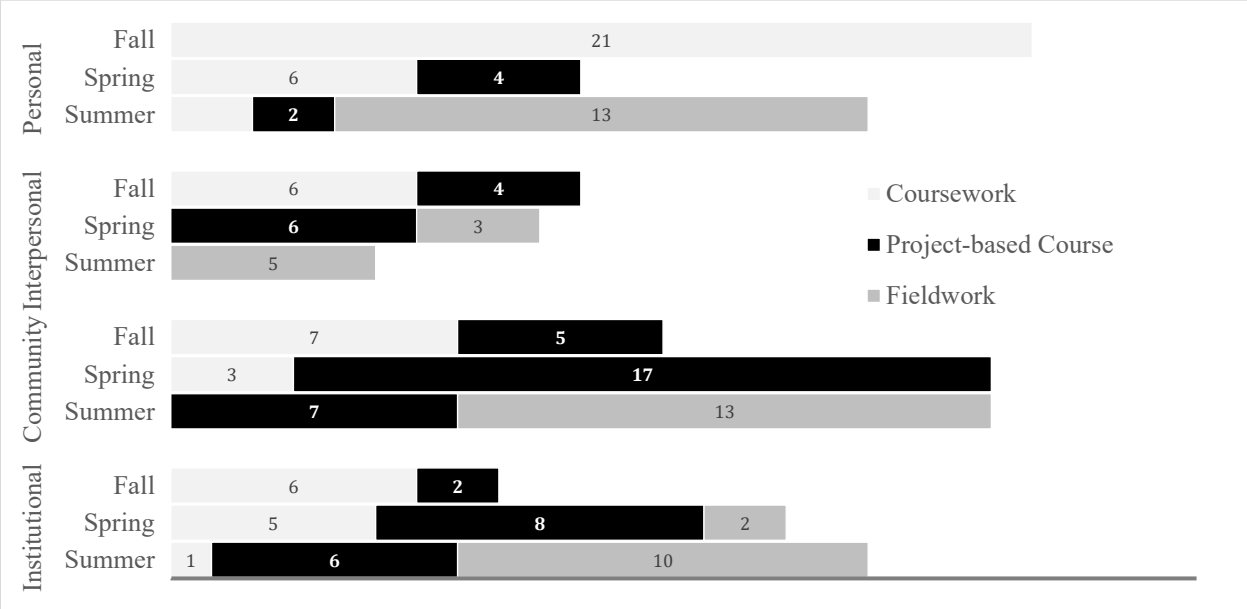

Figure 4-2 Reported Increases in Social Justice Self-Efficacy

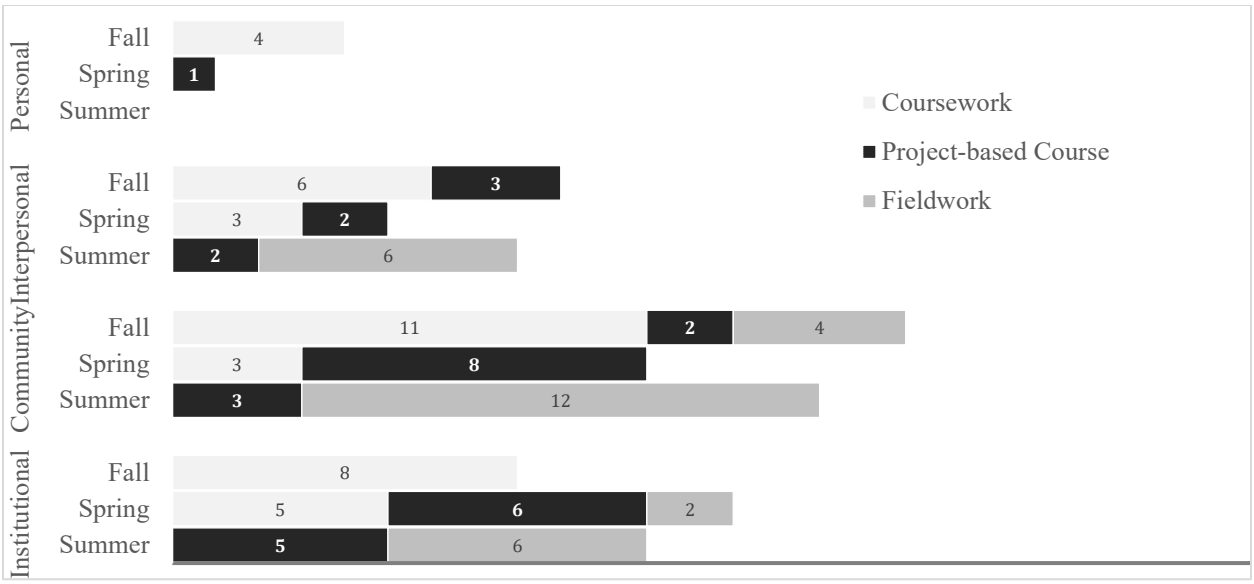

Figure 4-3 Reported Decreases in Social Justice Self-Efficacy

In the following sections, we examine the developmental trajectories of each form of SJSE, drawing on focal students' experiences to illustrate how different educational components contributed to students' evolving confidence in creating social justice change across personal, interpersonal, community, and institutional dimensions.

Personal SJSE: Examining Biases and Worldview

Students' ability to examine their biases and worldviews showed consistently positive development throughout their first year. Quantitatively, this domain showed the strongest positive trajectory among all SJSE dimensions, with students reporting increased confidence significantly more often than decreases across all three time periods. Our qualitative data from the six focal students further confirmed and contextualized these patterns, revealing how different educational components fostered this development.

Fall term

During the fall term, this study found that many students reported growth in examining their biases/worldviews, with 21 instances of increased confidence compared to only four decreases. These changes primarily occurred through coursework experiences.

During this time period, the focal students took similarly themed core courses at their respective universities, with titles varying across institutions (e.g., Global Development, Community Development, Critical Perspectives in International Development). These courses often covered comparable content, such as overviews on the history, current missions, and trends, as well as ongoing critiques of Humanitarian Engineering. Students also took specialized electives in subjects like policy, research methods, and environmental engineering. Although some project-based work was available, summer fieldwork and internships were still in the early planning stages. Students' reflections, thus, were primarily centered on theoretical coursework. Specifically, students reported experiencing worldview shifts as their coursework prompted questioning, dialogue, and introspection in how they understood their value and potential role in improving infrastructure disparities.

For instance, Teagan began developing a more critical perspective through historical analysis of global inequities. Her coursework helped her question previously accepted frameworks that guided her work: *"A lot of my classes dive into colonialism and the way the Global South has been purposefully underdeveloped to feed this power hunger from the north."* This critical lens led her to challenge basic assumptions in the humanitarian engineering field, including questioning frameworks like the UN Sustainable Development Goals, which she had once uncritically accepted as *"such a great idea"*. She found herself asking more probing questions like: *"Why do we define solving hunger just* [as] *getting food to people?"*

Gabby entered her program after being introduced to humanitarian engineering through a mission trip. Fall term coursework prompted deeper questioning of her motivations. She described having to *"do a self-check,"* questioning whether her interests stemmed from *"white privilege"* and reflecting on whether *"there was a religious aspect dominating my actions."* This self-examination represented an important development in her ability to examine the foundations of her professional aspirations critically.

Diverse classroom perspectives proved particularly powerful in expanding students' worldviews. Nate described how a class with students from Guyana, Egypt, Saudi Arabia, Nepal, and Uganda created regular opportunities for examining his own biases through conversations centered on classmates' lived experiences with racial dynamics, economic systems, and infrastructure needs. He reflected that *"every conversation we had was just full of diverse perspectives,"* noting how this directly challenged his assumptions about development: *"For the first time I wasn't just surrounded by Americans... hypothesizing, but* [hearing] *how* [development projects] *come up in their countries or situations."*

Similarly, Gabby described how impactful it was for her as international students in her class would approach case studies of engineering projects in marginalized communities with completely different perspectives than her own: *"*In this class discussion, we had international students [that] had a different opinion on how they would approach it based on their own experience... And I [would walk away thinking] 'Oh, [their approach] makes sense. I'm [...] wrong." She explained that this prompted a process where she *"really had to think about humbling myself"* as she encountered valid alternative perspectives to HE work.

Spring term

In the Spring term, many students continued to report improving their ability to examine biases and worldviews, though at a somewhat moderated pace (10 increases, one decrease).

For instance, Gordon, passionate about mitigating the impacts of climate change and environmental degradation, came to his spring term courses feeling overwhelmed about the complexities and limitations of individual action to address global inequality, concepts addressed in his fall term courses. These concerns led him to consider "*taking time away from development*" work after graduating and focusing solely on living a personally sustainable lifestyle. However, while feeling overwhelmed, he intentionally enrolled in life cycle analysis and sustainable systems classes to expand his worldview and dive deeper into his specific interests in sustainability. As he stated, these courses helped him "*take a step back and look at the bigger picture... and look at what my assumptions were and* [know] *what's a really important thing to look at.*" This continued motivation to expand his worldview allowed Gordon to maintain optimism about his social and environmental career goals.

Summer term

Summer experiences showed continued personal worldview development (17 increases, zero decreases).

This period marked a significant shift toward field-based work and practical application, with four of the focal students engaging in extended research visits to marginalized communities, including some outside of the US. Their activities ranged from thesis-related fieldwork, including stakeholder interviews, infrastructure assessments, and technical analyses such as GIS mapping and water testing, to professional development through internships and part-time work at humanitarian engineering organizations. The summer also provided opportunities for professional

growth through conference attendance, allowing students to build networks within the humanitarian engineering field. Across these experiences, students had to test their biases and further expand their understanding of the world as they confronted the professional realities of humanitarian engineering work beyond the university setting.

For instance, Teagan's summer internship at an organization helping indigenous communities make legal claims for their water rights exposed her to significant gaps in her knowledge about indigenous communities in the US. This experience prompted a growing desire to critically reflect on her positionality and educate herself on indigenous history and perspectives, as she noted: *"I'm trying to engage more in what it means to work for indigenous communities... I live on this land and I don't know what really that means."*

Similarly, Gabby spent the summer collecting data on water and sanitation systems in marginalized Caribbean communities. As she faced difficulties getting community stakeholder input for her project and finding households that had the WASH systems she was studying, she was confronted with how limited her initial assumptions about these communities had been. Specifically, she discovered that local interest in her technology was not as high as she had assumed, and that local research assistants operated with different timelines and expectations. This critical self-reflection strengthened her personal SJSE as she expanded her worldview beyond American-centric assumptions about infrastructure needs and research practices in different cultural contexts.

Interpersonal SJSE: Advocating Dialogue

Students' confidence in challenging others' biases and deepening others' understanding—their interpersonal social justice self-efficacy—showed varied development throughout their first year. Quantitatively, this domain exhibited more fluctuation than examining biases/worldview, with a

less consistent pattern of increases versus decreases across different time periods. The focal students' experiences revealed how this variability stemmed from the different challenges they encountered when attempting to advocate across power differentials in academic, professional, and community contexts.

Fall term

During the fall term, a moderate number of students perceived growth in their ability to advocate for social justice through dialogue, with 10 increases versus nine decreases.

Fall term classes gave some students experiences engaging in advocacy dialogue through peer discussions about perspectives on and critiques of humanitarian engineering projects. For instance, Nate's course, which had a substantial number of international students, gave him the opportunity to learn how to navigate conversations across cultural differences. He described initially feeling inhibited in his diverse peers explaining he was *"very hesitant of speaking my mind because this whole idea of white privilege."* However, conversations with his cohort increased his confidence as they assured him that *"we value your opinion just as much as the others because it's framed from one type of person's experience and perspective in global equity."* Nate described gaining the confidence to engage in difficult conversations across cultures, including on differences in opinions about international development, by learning to position his perspective explicitly: *"These are my thoughts, and I'm not telling you that this is better."* This was an empowering opportunity for Nate, as despite his previous professional experience working with international teams, he explained the uniqueness of these experiences: *"*[my past conversations in internationally diverse groups] *wasn't as much like spouting theory or thoughts or perspectives and having these courses have really made me more comfortable being able to do that."*

Students could also experience decreases in their confidence to engage in advocacy dialogue when their fall term courses taught them about social justice issues in humanitarian engineering efforts. Lisa had spent multiple summers working for an organization that constructed basic services in Latin American countries, like drinking water systems and school buildings. Her fall term courses prompted her to recognize problematic practices within that organization. However, despite this new knowledge, she found herself feeling *"scared"* to express her concerns to leadership in the organization, especially after observing a co-worker being *"socially alienated"* for speaking up about different practices. As she explained: *"*[In] *the past I would not even have recognized that those were fishy issues... in these past three weeks of classes, I've learned so much more about the social side of aid and development work than I ever knew before, and now I recognize that I see that some of these* [processes] *are wrong."* For Lisa, heightened ability to critique humanitarian engineering practices from her fall term courses outpaced her confidence in speaking to coworkers about them.

Spring term: Balancing Professional Identity and Advocacy

In the spring term, more students reported positive development in their advocating dialogue abilities, with nine increases compared to 5 decreases in their interpersonal SJSE. For the focal students, both increases and decreases in self-efficacy were related to diving into their specialized interests and career goals in humanitarian engineering through both project-based work and elective courses.

For instance, Lisa reported a newfound confidence in advocating dialogue with leadership at her former humanitarian engineering organization. Specifically, she drew on knowledge from her water and sanitation coursework to advocate for changes to how the organization was constructing and engaging with community partners in implementing sanitation services. She stated: "*I pitched*

the idea of including menstrual hygiene education in [the] *wash* [interventions they provide to communities]," which was an aspect of WASH she was increasingly hoping to professionally engage in. She also advocated for accessibility improvements to bathrooms she learned about in the course, noting, "*I have built bathrooms with* [this organization] *and I know for a fact they are not handicapped accessible*." She suggested concrete improvements that were cost-effective, like adding support bars, *"even if you just put a bar in the bathroom for... an old person to hold on to,"* it would be an improvement.

Other students experienced decreased confidence in advocating dialogue despite gaining more knowledge in specific HE topics. For example, Remy, who was researching how to make mining operations in low-resource communities more reciprocal and empowering for miners, spoke with a student researcher who was developing technology for marginalized miners that reduced the negative health effects of their job. During this interview, Remy noticed problematic attitudes in how the student researcher talked about the miners, but felt constrained by his role as an interviewer. He explained his hesitation to speak up, stating, *"We were doing research... I don't think* [I could have said] *hold on, let me explain to you the whole history of development."*

Summer term

During summer, students experienced significant challenges in their interpersonal SJSE development, with more reporting decreases than increases (5 increases versus eight decreases). This period marked a testing ground for the focal students' ability to navigate cross-cultural conversations and advocacy as they transitioned from theoretical understanding to practical application in fieldwork and professional settings.

For instance, Remy gained interpersonal skills during his summer research in Colombia. After struggling in the spring term to challenge problematic perspectives during research interviews, he learned from a mentor that "*you can be a neutral observer and still be an advocate through the way that you do research*." Specifically, he developed sophisticated interviewing techniques to expose inequities in mining operations. By carefully sequencing his questions, he would engage in dialogues that led mine and processing plant operators to consider the experience and expertise of miners.

Meanwhile, Gabby encountered varied success in cross-cultural communication settings. Gabby gained some comfort advocating with specific groups, noting "*it was easier for me to do that because... I was able to ...connect with them* [as] *a female*". However, her interpersonal SJSE was challenged by complex positionality considerations: "*this is where like, the white privilege comes into play... do I feel comfortable changing* [local community members'] *behavior by myself. Not really*." These concerns were amplified by gender dynamics, leading her to question her ability to effectively communicate with "*the men community*" especially as "*an independent female going over there*".

Community SJSE: Improving Access to Resources in Communities

Students' confidence in improving equitable access to resources and services in marginalized communities—their Community SJSE—showed complex development patterns throughout their first year. Quantitatively, this domain demonstrated substantial fluctuation, with fall term coursework producing significantly more decreases than increases, followed by a more positive spring term dominated by project-based work increases, and culminating in a mixed pattern during summer fieldwork experiences. The focal students' experiences illuminated how this volatility stemmed from their evolving understanding of community needs and power dynamics, as

theoretical critiques initially undermined their confidence in technical solutions, while subsequent hands-on experiences helped them identify specific pathways for meaningful community engagement such as through locally-appropriate infrastructure, behavior change approaches, and participatory design methodologies.

Fall term

Many students expressed moments of decreased confidence in community advocacy in their fall term. This pattern was particularly pronounced in coursework experiences (11 decreases, seven increases).

For the focal students, this decrease in self-efficacy paralleled their transformative theoretical education during core classes. While these same courses strengthened students' ability to examine personal biases, they simultaneously undermined confidence in community-level impact. Teagan, who entered the program with substantial prior experience implementing infrastructure projects, described her fall term as "*such a culture shock*" that would "*bust open your whole point of view*" through readings about "*the harmful history with development*" and ongoing issues of "*neoliberalism and colonialism*." She began questioning her previous career aspirations, shifting from believing she could make a difference in marginalized communities to expressing a crisis in confidence: "*I felt like I was so stupid to think that I was making a difference* [with my past HE infrastructure implementation projects] *because* [international development] *is all harmful anyways. And I was like, 'Why do we even do this work? Why are we even going to other countries and telling them what's best for them?... Development work is a scam.*"

Similarly, Remy had entered his graduate program passionate about infrastructure equality after visiting a multinational mining corporation in a Latin American country and seeing how its

operations harmed natural resources. His coursework helped him recognize a broader pattern in how international engineering projects have historically affected communities: "*Humanitarian engineering... projects in the past have contributed to, (and) reinforced globalization, which has increased poor country's dependence on larger countries, even though it's under the guise of trying to do something productive*." This education led him to wrestle with a fundamental concern on whether any engineering projects have had or could have lasting positive change on marginalized communities, asking: "*how engineering can be used...to start to close that inequality gap*".

However, fall term education could also improve community advocacy. Through a webinar series hosted by her professor, Gabby heard from HE practitioners in roles across government, consulting, and the private sector. This exposure to diverse career opportunities helped her move beyond the assumption that HE work was limited to international nonprofits, expanding her understanding of her opportunities to engage in community advocacy and led to a specific interest in government roles, particularly with agencies like the EPA. As she expressed, "*So now I'm exploring, where do I want to* [go], *what do I want to do*?"

Spring term

Following this period of disillusionment, in the spring term, more students reported increases (20) than decreases (11) in community advocacy self-efficacy, particularly through project-based experiences.

The focal students developed greater confidence in community advocacy as they learned specific methodologies for infrastructure improvement in their coursework and applied these approaches in hands-on projects. For instance, Gabby developed her self-efficacy by collaborating with a faculty mentor to create a thesis proposal focused on improving hot water systems in a low-income

country. Rather than feeling overwhelmed by the numerous global infrastructure disparities and their systemic nature, this focused project allowed her to channel her skills toward a specific technology with potential community benefits. Gabby's confidence grew further as she incorporated ethical practices from her coursework into her research methodology, noting she was *"putting into practice... what I learned from Sustainable Development and* [my] *environmental justice classes."* Her commitment to social justice principles was evident in her plan to integrate participatory research methods: *"I think it's important to allow some place for people's voices to be heard... combining a social science* [data collection] *aspect ... with the water parameters that I test for."*

Remy gained confidence in community advocacy as he designed summer fieldwork exploring how locally owned processing facilities could empower marginalized communities to achieve autonomy from multinational mining corporations. This growth directly addressed his fall term concerns about whether humanitarian engineering could reduce rather than reinforce global inequalities. His coursework helped him develop a conceptual framework where *"engineering projects* [could] *sever off some of those dependency ties on more wealthier nations,* [and] *large-scale development projects...* [infrastructure projects can provide] *local autonomy that can start to give* [marginalized communities] *independence from these larger systems of globalization."* While he still carried concerns about whether reforming exploitative multinational firms was possible, Remy was able to develop his community advocacy confidence by focusing his thesis on promoting local infrastructure ownership—an approach he found both practical and inspiring as a pathway for communities to regain control over their essential resources and services.

During the spring term, some students experienced decreased community advocacy self-efficacy as they confronted the unique challenges and specialized skillsets required in their areas of interest.

Lisa, who entered her program passionate about improving global access to menstrual hygiene, found her confidence diminishing as she gained deeper insights into the complexities of cross-cultural work. Through her course on WASH in low-income countries, she critically reflected on her positionality and the limitations of her perspective: *"Who am I to develop a curriculum on* [menstrual hygiene] *when I don't know* [local] *thoughts on it? If I were ever to be in a position to incorporate menstrual hygiene education in WASH work, I would for sure need to work with women from that country or community, because I wouldn't know what* [is] *taboo around it without having that local knowledge."* Her community advocacy self-efficacy decreased further as she actively searched for job opportunities that aligned with her specific interests in menstrual hygiene while respecting her ethical concerns about displacing local expertise: *"I can't take the job of someone in a lower- or middle-income country. I'm looking for a way that I can still provide support, but from the States, and I don't know exactly how to do that."*

Summer term

During summer, there was significant volatility in community advocacy self-efficacy, particularly for students partaking in fieldwork, with 13 reported increases and 12 decreases. As the focal students applied their theoretical knowledge in fieldwork settings and internships, they simultaneously discovered their unique capabilities in real-world contexts while confronting the complex realities, barriers, and benefits of humanitarian engineering careers.

For instance, fieldwork allowed Remy to develop greater confidence in his value to humanitarian engineering projects, as he gained specialized expertise in his research area. After spending a few months collecting interview data in Latin America, he reflected, *"I felt a lot more competent about what I was* [researching]*."* Furthermore, his community advocacy self-efficacy increased as he discovered and partook in methods for disseminating his research findings to community members

in meaningful ways, stating *"*[I have ideas of] *good ways to share my findings in a way that would go beyond academic publications,"* such as presenting on local television, organizing community forums, and sharing results with government agencies.

Similarly, Lisa experienced increased self-efficacy after completing a two-month internship at a humanitarian engineering WASH organization. She became invigorated by their behavior change approach to increasing infrastructure access, saying *"*[behavior change] *is completely people focused...* [in other processes] *you* [may] *go and build a water system for a community and dip out - that's obviously not the work. People might not be receptive to it. They maybe didn't even want it,"* and hoped to keep using behavior change methods in her future career. Furthermore, she developed greater trust in humanitarian engineering organizations' ability to create positive community impact by witnessing specific ways they helped individuals. She noted that this organization was valuable because they were *"helping people by giving them a clean space... reducing the amount of diseases* [and these structures] *provide safety for women and girls"* and allow for *"privacy and dignity."*

However, these testing grounds of fieldwork could also significantly diminish students' community advocacy confidence. As Gabby conducted data collection for her thesis on hot water heaters, she severely lost confidence in the value of her research. First, she lost confidence in the relevance of her topic when she discovered that local communities used and maintained hot water heaters at a much lower rate than she had previously thought, revealing unexpected social and cultural barriers to their adoption. She stated: *"So I had kind of a mental crisis of like, what is this research, what is the purpose of this research... I wanted to impact the whole island, I can only impact eight people."* This realization of how mistaken her assumptions were before traveling to the communities, combined with her difficulty collaborating with researchers from different cultural

backgrounds, diminished her confidence in international engineering work. She reflected, *"I have a little bit less confidence in the whole international engineering world... I'm not as eager about it anymore."*

Institutional SJSE: Transforming Exploitative Policies, Cultures, and Norms of Organizations

Students' confidence in their ability to transform systems, policies, and institutional practices—their institutional social justice self-efficacy—exhibited significant fluctuation. Quantitatively, students experienced both substantial growth and challenging setbacks in their confidence to create organizational change across the three educational periods. The focal students reflected on an evolving understanding of institutional power structures. They alternated between periods of disillusionment about large-scale change and renewed optimism through identifying specific institutional contexts where they might effectively apply their technical expertise and social justice values to transform exploitative policies and practices.

Fall term

Fall term experiences led to nearly equal numbers of students reporting increased and decreased confidence in their ability to transform institutional systems (8 increases and eight decreases). Similar to the other forms of self-efficacy in the fall term, the focal students reflected that their institutional SJSE was predominantly influenced by their theoretical coursework.

Fall term coursework often led to decreased institutional SJSE. Gordon, who had familial ties to a low-income country and had worked on year-long infrastructure implementation projects in low-income countries since his undergraduate years, was particularly concerned about increasing engineering projects' sustainability as he worried about how climate change would harm basic services in marginalized communities. However, he experienced a crisis of confidence when his

coursework exposed him to the systems that inhibit sustainability initiatives. His studies pushed him to confront how "*politics, economics, and all that" can override environmental and social priorities of organizations, countries, and individuals, leading to a disempowering realization that he was "just a little piece of a way bigger puzzle*." Gordon used ongoing political conflicts in Europe to illustrate how larger forces can "*bring* [efforts to make organizations more sustainable] *all down, and that are way more powerful than what progress you think you're making*," highlighting the "*demoralizing*" recognition of systemic inertia. This growing awareness of institutional barriers manifested even in small-scale examples - *"*[we tell communities] *we should recycle plastic, but then like Oh, that's not convenient* [enough for people to actually do]." The overwhelming evidence of institutional obstacles to global sustainability led him to question "*what even is the point of doing anything* [trying to increase sustainability]?"

Similarly, Nate came to his graduate program already questioning the effectiveness of development work. His previous role at an international HE organization, where he worked on small business development education and resource provision, had exposed him to the bureaucratic challenges in the field. However, his initial skepticism transformed into deeper disillusionment after encountering course readings from "*economists and philosophers and development professionals*," which revealed decades of critique showing "*how things have just never worked*" in development. He connected these theoretical critiques to his professional experience, observing how major HE organizations were "*still doing the same* [ineffective processes…] *putting different names on it or saying different buzzwords*." This growing awareness led to feelings of powerlessness when considering his potential impact on "*large, politically connected organizations with so much power, influence, and funding*." His analysis of USAID's attempts at reform—where he described even official announcements of *"radical change"* as amounting to

"the most diplomatic way to say nothing at all"—exemplifies that he had come to view major development institutions as resistant to meaningful transformation.

However, Nate's experience also illustrates how students could simultaneously maintain optimism about institutional change despite this growing critical perspective. Despite acknowledging his approach might be 'very ambitious or naive even,' he drew hope from business concepts like disruptive innovation to envision new possibilities for transforming the development sector. Using the analogy of 'Blockbuster and Netflix,' he described how systemic change might come not from trying to reform existing institutions, but from creating alternative approaches that could eventually reshape the entire HE field: 'Netflix's idea was not to create a better Blockbuster. It was to do something different.' This entrepreneurial reframing transformed his institutional SJSE from feeling powerless against established organizations to taking concrete action, leaving his position at a traditional NGO to pursue more innovative approaches where he could 'branch off in a different direction' to create meaningful systemic change.

Spring term

Slightly more students reported increased confidence in causing institutional change (15 increases versus 13 decreases) during their spring term. The focal students envisioned actions for improving humanitarian engineering institutions as they inquired about specialized pathways for addressing the organizational policies and practices that had frustrated them through coursework, mentorship, and project-based learning.

For instance, Teagan came to her spring term feeling disillusioned with the humanitarian engineering sector. After spending months questioning *"Why am I even here?"* due to her deepening understanding of colonialism and problematic international development and aid

practices, she sought career advice from a guest lecturer. Specifically, she asked him how she could follow her career passions within traditionally problematic institutions. This conversation reframed her perspective from seeking ideal institutions to work for to recognizing how organizations could become sites for transformation through strategic engagement. She stated, *"It's not about finding the perfect place* [to work]. *It's about finding where you think you can make a change and fit in."*

Similarly, Nate used his project-based course on start-ups to envision and work on a specific avenue to address his frustrations with traditional aid organizations. Through his research and past work experience, he had identified and grown frustrated with how traditional aid processes often prevented grassroots organizations from being responsive to immediate needs because *"they don't actually have the ability to respond to* [a crisis] *or innovate or pivot because they have to file a huge report* [for the funding they are receiving]*... and by that time, it's three months down the line and another $3 million have gone out the window."* With his class team, he began developing an online startup, a platform designed to create direct connections between grassroots organizations seeking funding and corporate partners.

Summer term

Summer experiences revealed continued growth in institutional self-efficacy development, with more students reporting increases than decreases (17 increases versus 11 decreases) as they confronted the possibilities and realities of organizational change in project-based coursework and professional fieldwork settings. The focal students' experiences illustrated how direct engagement with institutions deepened their understanding of structural barriers while simultaneously providing opportunities to test and refine their approaches to creating change within specific organizational contexts.

Summer fieldwork experiences provided students like Nate the opportunity to explore in depth both the potential institutional changes they could implement and the practical barriers they would face in real-world organizational settings. For instance, Nate, still developing his startup focused on grassroots aid organizations, worked on policy and cultural initiatives aligned with social justice principles, such as establishing organizational pillars like ensuring the *"majority of our staff are international"* to avoid becoming *"a corporation that is ingrained with white supremacy"*. Further, he deliberately positioned his co-founder from a middle-income country as the head executive. However, as he moved from theory to implementation, he also confronted how organizational constraints could limit his social justice goals. When approached by a small refugee assistance group to be represented by his startup, he had to acknowledge, *"Unfortunately, right now you wouldn't qualify... we have to say no to some groups in order to build the credibility to eventually say yes."*

Similarly, Teagan deepened her understanding of institutional barriers specific to her career goals that diminished her confidence in creating systemic change. During her summer internship at an organization helping Indigenous communities claim water rights, she helped model water usage for tribal legal claims. While she saw this work as important, she also became more aware of the barriers created by institutional policies and norms that might prevent Indigenous groups from receiving needed water: *"How do you make that* [claim for water] *enforceable? Like in tribes' water rights... They're just so institutionally disenfranchised. How do you represent them in a court of law?"* Thus, while Teagan felt she could achieve some community impact through her internship work, it wasn't aligned with the scope or type of institutional change she was interested in making in her future career.

Meanwhile, Gordon's summer humanitarian engineering trip catalyzed an unexpected transformation in strengthening his institutional change self-efficacy, but only in specific contexts. A conversation with a young community leader who, like Gordon, was feeling disillusioned about creating change, sparked a crucial realization: *"if we both do that... if everyone that thinks this way does this, then we're never going to meet, and we're never going to work together on changing things and making things better."* This insight motivated him to channel his systems thinking skills toward institutional change at his own university, recognizing that *"I have an opportunity to influence a lot of things or like, have a lot of conversations with people in the leadership that can make actual changes."* He felt empowered in his thesis work, which focused on improving campus sustainability through initiatives like improving transportation access. His approach centered on making change accessible and was much more optimistic than earlier in the school year: *"Maybe people just need the tools... they're not against* [sustainability]*"* and *"everyone has power... in their own little space."*

Discussion

Theoretical Contributions

This longitudinal study revealed a distinct three-phase pattern in students' SJSE development across their first year of humanitarian engineering graduate education. The fall term emerged as a critical exposure phase characterized by dramatic shifts in students' SJSE, with coursework yielding high gains in examining biases/worldviews (21 increases, four decreases) while simultaneously generating significant decreases in community dimensions (12 increases versus 17 decreases) and balanced development in institutional dimensions (eight increases, eight decreases). During this period, students like Teagan questioned whether she was *"stupid to think that I was making a difference"* as they encountered diverse perspectives and critical theoretical frameworks

that fundamentally challenged their assumptions about humanitarian engineering. The spring term represented an integration phase where students demonstrated more balanced SJSE development across all dimensions as they identified specific approaches to social impact while maintaining critical awareness. Through specialized coursework and thesis development, students like Remy developed conceptual frameworks where *"engineering projects* [could] *sever off dependency ties"* from wealthier nations, helping rebuild their confidence in creating community-level change. Finally, Summer term, predominately through fieldwork and project based coursework served as an intense testing ground where students confronted the challenges of applying their developing SJSE in real-world contexts, experiencing both significant growth in personal SJSE (17 increases, zero decreases) and mixed development across interpersonal (five increases, eight decreases), community (20 increases, 15 decreases), and institutional dimensions (17 increases, 11 decreases). This period proved emotionally pivotal, as illustrated by Gabby's *"mental crisis"* when discovering unexpected cultural barriers to her research, yet also provided critical opportunities for students to refine their approaches to social justice work. Rather than viewing the initial decreases in SJSE as failures, this three-phase pattern suggests a necessary developmental progression where critical awareness precedes the formation of effective social change strategies. This pedagogical sequence, illustrated by the focal students' stories of first confronting personal barriers and fears in different social justice domains and then overcoming them in subsequent terms, allowed students to develop a nuanced understanding of systemic challenges before identifying specific, contextual approaches where they can effectively apply their technical expertise for meaningful advocacy efforts.

Beyond this developmental progression, our analysis revealed the complex, non-linear nature of SJSE development as students experienced simultaneous growth and setbacks across different dimensions. Rather than developing uniformly, students often maintained optimism in one area

despite challenges in others, particularly during fall term coursework (personal SJSE: 21 increases, four decreases; community SJSE: 12 increases, 17 decreases) and summer fieldwork (nearly balanced fluctuations across all domains). This resilience in maintaining at least one strong dimension of SJSE appears crucial for sustaining students' overall commitment to social justice work. For instance, Remy's trajectory illustrates this complexity—while his spring coursework helped him develop community SJSE through his thesis on locally owned processing facilities, his interpersonal SJSE remained challenged when he felt unable to confront problematic attitudes during research interviews. However, during summer fieldwork in Colombia, his interpersonal SJSE strengthened significantly as he learned advocacy techniques, which directly enhanced his community SJSE as he developed methods to share his findings through local television and community forums. This synergistic relationship between interpersonal and community dimensions highlights how growth in advocacy dialogue skills directly empowered his ability to create meaningful community impact. These findings align with Vera & Speight's (2003) and Neville & Mobley's (2001) conceptualization of interconnected spheres of social justice activity by demonstrating how growth in one sphere can either fuel or inhibit development in others, depending on contextual factors and individual experiences. These connections extend Miller et al.'s (2009) SJSE framework by demonstrating how these spheres develop asymmetrically in educational contexts, suggesting programs should consider how interventions differently impact each SJSE domain.

Practical Contributions

Understanding SJSE developmental patterns enables educators to provide targeted support during critical transitions. Fall term interventions should support students through the *"disorienting dilemma"* phase when confronting critiques of their humanitarian engineering aspirations. These

findings align with Niles et al.'s (2018) documentation of HE students feeling frustrated when confronting complex ethical dilemmas. Our research confirms that critical consciousness development does occur in HE graduate programs, but this challenging period requires deliberate support.

Litchfield and Javernick-Will (2017) found that socially minded engineers often face disillusionment when transitioning to careers if they struggle to align social justice aspirations with practical realities, potentially leading them to leave the field. We found that summer fieldwork experiences mirrored these career transitions, as they provided crucial testing grounds for students to apply approaches in real contexts. These summer experiences further underscore the importance of supporting students through these challenging phases, where they confront theory-practice gaps. By recognizing these developmental transitions, programs can implement interventions that validate students' experiences while providing tools to navigate these critical periods productively and use these navigational skills as they progress in their careers.

Indeed, the focal students demonstrated how appropriate support can transform SJSE decreases into productive learning opportunities. Students navigated disillusionment more effectively through targeted coursework addressing specific concerns; for instance, Gordon enrolled in sustainability systems classes when feeling overwhelmed about individual impact limitations, helping restore his optimism toward environmental goals. Other students relied on Mentorship; when Teagan questioned working within humanitarian organizations after learning about their colonial legacies, practitioner guidance helped her reframe her perspective toward creating change from within existing institutions. Finally, strategic career repositioning also enabled students to refine their social justice approaches; after Gabby's fieldwork revealed unexpected cultural barriers

to technology adoption internationally, she pivoted toward domestic environmental work that better aligned with her values and communication preferences.

A theme across the focal students was that they benefit from identifying specific contexts where they can build confidence through tangible impact rather than attempting a system-wide transformation. For instance, students found renewed optimism by focusing on smaller and more local efforts where they could implement specific actions and changes rather than trying to address a global systemic issue. when students feel overwhelmed by the vastness of social inequality, they should be encouraged to dive into their specific interests, build context-specific knowledge, and identify social justice issues within their areas of expertise.

Another trend across students was the importance of opportunities for social justice advocacy practice in building confidence for taking action, even when students initially doubted their abilities. For instance, students engaged in conversations with diverse peers who held differing opinions, which helped them develop cross-cultural communication and interpersonal advocacy skills. Further, thesis development, where students had mentorship from advisors on applying technical skills for practical benefit, and project planning, including designed fieldwork where students worked for communities, allowed students to develop self-efficacy towards practical advocacy as they were compelled to act for positive good despite the previous theoretical uncertainties they carried with them from their fall term. This productive integration of theoretical coursework with experiential learning aligns with established humanitarian engineering curriculum design, where project-based work complements theoretical instruction to develop practical advocacy skills alongside critical awareness of systemic issues (Smith, 2020). Programs should, therefore, support and encourage students to engage in social justice activism despite initial fears, providing structured opportunities for advocacy practice.

Finally, the theoretical finding of the synergistic relationship between SJSE domains, confirmed by focal student experiences, reveals the importance of considering each SJSE dimension separately while recognizing their interconnections, particularly how interpersonal confidence impacts community-level effectiveness. For instance, strong interpersonal skills allowed students to engage knowledgeable community members in productive dialogues that strengthen community outcomes. When this self-efficacy was not present, cross-cultural communication challenges limited the ability to create positive outcomes. These findings suggest humanitarian engineering programs would benefit from a greater emphasis on developing students' interpersonal SJSE. While current literature prioritizes technical, cross-cultural, and community engagement skills, our research indicates that confidence in navigating professional interactions is crucially influential in students' capacity to create meaningful community impact.

Limitations and Future Work

Our findings also highlight several promising directions for future research. First, we focused on students who began programs in Fall 2021 and completed all four interviews. This enabled us to track SJSE development, but limited the number of students we could include. Future work could expand this sample size and include students who enter programs at different times. Next, studies could compare and examine different program structures and pedagogical approaches to determine how these influence SJSE development. Finally, longitudinal studies following students from graduate school into their early careers could illuminate how different SJSE development patterns influence practitioners' ability to create lasting change in humanitarian engineering practice.

Conclusion

This longitudinal study of humanitarian engineering graduate students reveals a distinct three-phase pattern in social justice self-efficacy development: critical exposure through fall term

coursework that increases personal SJSE while often decreasing community and institutional dimensions; integration during spring term experiences where students develop more balanced SJSE by identifying specific approaches to social impact, with notable improvements in community SJSE through project-based learning; and practical testing during summer fieldwork where students confront real-world challenges, experiencing continued growth in personal SJSE while facing both significant gains and setbacks in community and institutional dimensions. Rather than developing uniformly, students experience non-linear, asymmetric growth across SJSE dimensions, often maintaining optimism in one area despite challenges in others.

Findings suggest that humanitarian engineering education could support students for social justice advocacy when programs provide targeted support during critical transitions (such as mentorship from practitioners during fall term disillusionment or structured reflection during summer fieldwork challenges), encourage smaller, actionable steps with context-specific engagement rather than system-wide transformation, create opportunities for social justice advocacy practice, and develop students' interpersonal SJSE through guided practice in challenging peers' and coworkers' conceptions of engineering roles and responsibilities alongside other dimensions. By preparing graduates who can confidently engage in social justice activism across multiple dimensions, humanitarian engineering education can transform not only individual career trajectories but also the broader engineering profession, helping to create a field that is more responsive to the needs of marginalized communities and committed to dismantling systems that perpetuate inequality.

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Chapter 5. The Unseen Labor of Being Included: Community Cultural Wealth and Supporting Students With Familial Ties to Low and Middle-Income Countries in Humanitarian Engineering

Introduction

To better prepare students for the sustainable development and humanitarian aid workforce, humanitarian engineering (HE) education programs are increasingly advocating for the enrollment and retention of students with significant ties to low- and middle-income countries (LMICs). These individuals have valuable cultural and social capital, including cross-cultural competency, non-Western development perspectives, and established grassroots networks (Frennesson et al., 2022). By graduating more students with these backgrounds, HE programs aim to cultivate the future leaders of the HE field and create enriching learning environments where diverse perspectives can be shared.

While preliminary research suggests HE programs can attract students from marginalized backgrounds (Swan et al., 2014), studies specifically exploring the experiences of LMIC-tied students within HE graduate programs remain scarce. There is a need to study these experiences, especially given reports of LMIC HE practitioners feeling tokenized, undervalued, and overworked (Peace Direct et al., 2021). This raises a critical concern: the field may seek to increase the use of LMIC practitioners' insights, skillsets, and values without implementing structures to do so in a supportive and equitable manner. Broader research on diversity initiatives in education demonstrates that without careful attention to the experiences of marginalized students, they often bear disproportionate burdens, such as enduring hostile climates and culturally irrelevant pedagogy (Yosso et al., 2022).

This study addresses this gap by investigating the factors contributing to creating supportive learning environments, which are learning environments that LMIC-tied students perceive as equitable and prioritize their educational development and well-being. Drawing from 69 interviews with 19 LMIC-tied students, we analyzed interviews using the community cultural wealth (CCW) framework. This is an established framework for recognizing the diverse forms of cultural and social capital that marginalized students contribute to engineering education (Burt et al., 2023; Yosso, 2005). Furthermore, to help identify supportive learning environments, we explored institutional practices, which are the established educational procedures and processes, that can mitigate negative experiences or burdens of holding and sharing this capital in HE learning environments.

Background

We provide a background on the importance of diverse social and cultural capital within humanitarian engineering (HE) and the need to study the perspectives of students with familial ties to low and middle-income countries (LMIC-tied students) enrolled in HE programs before discussing the theoretical lens we employed to analyze these perspectives.

Challenges and Opportunities in Including LMIC Perspectives in Humanitarian Engineering

Rooted in colonialism, HE has historically denied LMIC communities' agency and control over their development (Lucena et al., 2010), leading to projects that perpetuate a Eurocentric vision of *"betterment"* and are mismatched with local contexts (Peace Direct et al., 2021). Recognizing these historical limitations, the HE field is shifting towards greater inclusion of LMIC perspectives. This is driven by the recognition that diversifying staff and leadership can move the field beyond Eurocentric development goals (Peace Direct et al., 2021) and that LMIC practitioners possess

valuable Indigenous knowledge and a deep understanding of local contexts, including community-specific communication skillsets and environmental, socio-economic, and technological solutions developed over generations (Roborgh et al., 2024; Senanayake, 2006).

This shift has led HE stakeholders to increasingly advocate for the enrollment and retention of LMIC-tied students in HE educational programs (Burleson et al., 2023b). HE educational programs have the potential to attract and retain these students. Students from LMICs have reflected on wanting to be humanitarian engineers to support their own country and, therefore, report being highly motivated to acquire relevant skills and pursue a degree (Park et al., 2021). This aligns with broader research indicating that marginalized students are often drawn to engineering to help others (Barrington & Duffy, 2007; Brubaker et al., 2017), and HE projects are avenues for students to express their motivations for social good (Litchfield & Javernick-Will, 2015). Further, incorporating humanitarian components into undergraduate design classes has been shown to improve retention rates of marginalized students (Adams & Burgoyne, 2017).

However, despite this potential, challenges persist in recruiting and retaining LMIC-tied students. Some HE programs report difficulties increasing LMIC enrollment (Thomas et al., 2021), while others find they disproportionately attract domestic students (Smith et al., 2018).

While research on LMIC-tied students is lacking, LMIC practitioners have reported significant hardships in the HE field. Multilingual LMIC practitioners have been alienated by the sector's linguistic norms, which favor native English speakers, and have had their contextual expertise undervalued, particularly their skills in navigating local conflicts and their local language proficiency (Peace Direct et al., 2021). The HE industry has also been criticized for nationality-based pay discrepancies (Peace Direct et al., 2021), and one study revealed that 85% of employees

of color in the development sector felt promotions were inaccessible (Bond, 2020). While these challenges facing LMIC practitioners in the humanitarian sector are documented, we need to better understand the educational experiences of LMIC-tied students, especially how similar challenges might manifest as their diverse forms of capital are increasingly valued and sought after.

Categorizing the Social and Cultural Capital of Marginalized Students Using the Community Cultural Wealth Framework

University education, heavily influenced by colonialism, was designed to support and teach the values, culture, and aspirations of the dominant classes in predominantly white countries and frequently overlooked the diverse assets marginalized students carry (Bourdieu, 1977). community cultural wealth (CCW) offers a critical framework for challenging this oversight and recognizing the unique forms of capital that these students possess (Yosso, 2005). CCW acknowledges that marginalized students bring a wealth of valuable assets to education, including aspirational, linguistic, social, familial, resistance, and navigational capital (as detailed in Table 1), and is a framework with established use in engineering education research (Denton et al., 2020).

Table 5-1 Six Forms of Community Cultural Wealth

Form of Community Cultural Wealth	**Definition (Yosso, 2005)**
Aspirational Capital	The ability to maintain hopes and goals for the future, even in the face of real and perceived barriers.
Linguistic Capital	Communication skills in multilingual communities, navigating communication across different groups, and engaging in storytelling and oral history traditions.
Social Capital	Networks of people and institutions that students of color utilize as resources and support.

Familial Capital	A greater understanding of community history and cultural intuition, strengthened aspirations, and a sense of obligation to give back to one's community.
Resistance Capital	The knowledge and skills fostered from resisting subordination, resulting in the ability to increase equality.
Navigational Capital	The inner resources and strategies that students of color use to navigate institutions not created for them.

During this shift towards verbally valuing the diverse forms of capital of LMIC practitioners, this framework allows us to examine the experience of LMIC-tied students sharing and utilizing their social and cultural capital in HE education.

Contextualizing Burdensome and Supportive Learning Environments for Marginalized Students Using a Critical Race Theory Lens

To better understand students' perceptions of how programs support or place burdens on them for their cultural and social capital, we employed critical race theory (CRT). CRT offers a valuable framework for understanding marginalized students' experiences within the US educational system by examining how systemic racism and inequity persist in these institutions (D. Bell, 1992). It challenges seemingly neutral norms and policies that perpetuate marginalization and emphasizes the importance of utilizing the lived experiences of marginalized communities to understand contemporary forms of oppression (Solórzano & Yosso, 2002). While CRT scholarship initially focused on the experiences of students of color, it has been expanded upon to contextualize the challenges various marginalized students face to the systemic inequities and civil rights movement within the US. Consequently, by applying a CRT lens, we can connect the experiences of LMIC-tied students within HE programs to the broader scholarship on diversity and equity in education.

CRT scholarship illuminates how US educational programs, since the 1954 *Brown v. Board of Education* ruling to desegregate schools, have historically placed the burden of diversifying education on marginalized students. W.E.B. Du Bois famously critiqued integration, arguing that it could divert attention from achieving genuine educational equity and harm Black students' educational achievement (Du Bois, 1935). Indeed, Black students were subjected to mandatory busing in hostile and violent environments (Delmont, 2006)). Furthermore, many school districts limited access to academic enrichment by channeling White students into college preparatory programs and disproportionately placing students of color in vocational or remedial tracks (Oakes & Lipton, 2004). Studies have documented the harms of past integration efforts on students of color, such as lower math achievement when they are a small minority in predominately white schools and lower graduation rates in racially mixed schools, potentially due to increased discrimination as their growing numbers are perceived as a threat to existing power dynamics (Darity et al., 2015; Diette et al., 2021; T. J. Yosso et al., 2022).

Marginalized students continue to be burdened by diversity efforts today. Universities often focus primarily on recruitment rather than creating truly inclusive learning environments. This approach has been criticized for relying "on populations of color to not only deliver racist institutions from the appearance of racism but also receive the shockwaves of aggressions from those not fully complicit or conscious of how this desired object threatens their status" (Patel, 2015), which can create a hostile environment where these individuals are expected to shoulder the responsibility for institutional change (Love, 2023). Furthermore, students may be tokenized or expected to serve as representatives of their race in discussions about race, colonization, or social justice, often for the emotional satisfaction of White individuals rather than for the educational benefit of marginalized communities (hooks, 1994; Hubain et al., 2016).

To address these challenges, scholars have explored institutional practices and educational procedures that foster meaningful diversity while minimizing burdens placed on marginalized students. This includes dismantling structures that impede student well-being and prioritizing their holistic needs (Carter, 2004; Morris, 2004). For instance, scholars recommend designing campus services like academic advising, tutoring, and career guidance to meet the intersectional needs of students from diverse backgrounds, acknowledging their unique experiences of historical and contemporary exclusion (Hailu et al., 2024). Ladson-Billings (1995) introduced the concept of culturally relevant pedagogy as a way to center the experiences and cultures of students traditionally excluded from mainstream educational settings, emphasizing the importance of students developing and maintaining positive cultural and ethnic identities. Historically, Black schools during Jim Crow segregation exemplified this approach by leveraging community support and the cultural capital of Black educators to create positive learning experiences and empower students as agents of change (Walker, 1996). Culturally responsive teaching has been identified as particularly important in STEM fields, where it can counter negative stereotypes and racialized narratives that impede students' learning (Cox & Malcom-Piqueux, 2022). For example, studies have found that Tibetan students in engineering courses particularly valued learning about technology and society in their host country of India, engineers' work in industry, technologies used in various contexts, and projects demonstrating how engineers can help alleviate poverty (Mercado-Santiago, 2014)

Research Overview

This research investigates how to cultivate supportive learning environments for LMIC-tied students. It draws on the CCW framework to identify the diverse forms of capital these students possess and utilize in HE spaces and CRT to analyze how they are supported and burdened in sharing their capital. Specifically, this research asks:

What institutional practices create supportive learning environments for LMIC-tied students?

Methods

Data collection

We selected six US graduate programs for this study. These programs were chosen because they offer master's or doctoral degrees in humanitarian engineering (HE) and have mission statements focused on educating engineers to address the needs of marginalized communities, particularly those in low- and middle-income countries (LMICs).

We recruited students to participate in the research through email advertisements distributed by program directors and professors. Students were initially recruited for a larger study on HE graduate education. For this specific study, we focused on participants with at least one parent from an LMIC, ensuring a connection to these communities. These students had varied experiences in LMICs, ranging from lifelong residency and citizenship to shorter visits, family connections, and varying degrees of cultural influence from those countries. Regardless of the extent of their engagement, their ties to these countries significantly shaped their educational and career aspirations. Our final study sample consisted of 19 students, with one to six students from each program.

We conducted 69 interviews with these 19 participants between winter 2021 and spring 2023. Interviews were incentivized with a $20 gift certificate and conducted via online video conferencing or in-person meetings.

The interview questionnaire was collaboratively developed by the research team, including an expert in HE education and a community cultural wealth (CCW) expert. To explore students' educational experiences, focusing on how their CCW was shared and integrated into their HE education, we asked broad questions about their feelings regarding their semester, coursework, and experiential learning opportunities. To gain insight into students' perceptions of their educational development, we also inquired about how these experiences were or were not helping them achieve their career aspirations and overall experiences as marginalized students in the program. We invited them to share instances where they felt supported within their education or extracurricular activities and when they encountered less supportive, burdensome, or hostile experiences, focusing on experiences they felt were influenced by their identities. To gain more pointed answers, we delved deeper into the CCW framework, asking students how their home life and the various forms of capital resonated with them and influenced their career aspirations and graduate school experience.

Protection of Vulnerable Populations

This study was conducted with the approval of the Institutional Review Board under protocol #21-0207. Audio recordings were transcribed using Trint (Version 1.0.68, 2023) and imported into the qualitative coding software NVivo (Version 14, 2022). All names and identifying information, including countries of origin and specific program affiliations, have been masked to protect the participants' identities. Quotes included in this article were carefully selected to maintain anonymity and prevent identification through context.

Qualitative Analysis

We employed a hybrid deductive-inductive approach to analyze the interview data (Spearing et al., 2022). Interview responses were segmented into meaningful units of analysis, each representing a distinct educational experience or belief. We first applied the CCW framework as our initial deductive coding structure (Yosso, 2005), followed by inductive subcodes that emerged from the data (Saldaña, 2013).

To investigate the impact of students integrating their CCW in their HE education on their educational experience, we began by coding for instances where students shared and utilized their CCW. This included situations where students shared insights with peers, used their capital to improve HE projects, or were prompted to discuss their capital by faculty. All such instances were coded into a broad "sharing CCW" category. Within this category, we sub-coded the quotes to characterize the six distinct forms of CCW described in Table 1.

For instance, the following excerpt was coded under “sharing CCW” and then "linguistic capital" as the student reflected on actively using their multilingual and cross-cultural communication skills during a research project:

Spending two months [researching] *in* [Latin America]…*One of the biggest jumps for me was being able to communicate in Spanish…all my ideas, even if they're complex and nuanced.*

Excerpts within the "sharing CCW" code were then deductively coded to identify "burdensome experiences" and "supportive experiences." A "burdensome experience" was defined as a student facing undue responsibilities, obligations, or hardships that led to a sense of strain, inequity, or disadvantage. Conversely, a "supportive experience" was defined as one where students felt they were in an equitable learning environment where their educational development and well-being

were prioritized. The previously mentioned quote about a student using their linguistic capital in Latin America was coded as "supportive." Although the student made significant efforts to communicate effectively in Spanish, they felt this was an emotionally sustainable experience that contributed to their learning and personal growth and were not experiencing inequitable burdens compared to their classmates.

The final analysis step involved an affinity grouping process to pinpoint critical practices of the learning environment that influenced students' sense of support and burden. We identified recurring factors correlated with "supportive" or "burdensome" experiences by comparing codes across participants and looking for commonalities in the institutional practices that shaped those experiences. These practices included established procedures and processes such as required courses, research methods, advisor relationships, class discussions, and advertisement of support services. By clustering these factors, we ensured internal consistency and representation of distinct facets of the learning environment.

Ultimately, we identified three key themes representing ways in which the sharing of CCW could lead to burdensome experiences for students. In response to our research question, these burdens allowed us to identify three institutional practices that fostered supportive educational experiences and mitigated the burdens associated with sharing CCW.

Authors Positionalities

As a research team composed of a White female PhD student in Civil Engineering, a Black female postdoctoral researcher in critical race theory, and a White female professor of HE, our initial focus on educational pathways in HE shifted after interviewing a cohort of graduate students, nearly half of whom were LMIC-tied. We became increasingly aware of the unique burdens they

faced, a realization amplified by our engagement with CRT, particularly the concepts of community cultural wealth and counter-narratives. We acknowledge the potential for our own implicit biases, as two authors are housed within a predominantly white institution with an HE program, and none of us possess the lived experience of being from an LMIC. To center LMIC-tied students' voices, we actively sought their feedback throughout the research process and engaged in ongoing reflexivity to understand how our positionalities might influence our interpretations.

Findings

This research revealed that students with familial ties to low and middle-income countries (LMIC-tied students) often experience burdens when integrating their community cultural wealth (CCW) into humanitarian engineering (HE) learning environments. However, we also found that these burdens can be mitigated through three key institutional practices, detailed in the findings section below.

Co-Creating Knowledge Through Reciprocal Exchange of Capital

This research revealed that LMIC-tied students may be disproportionately responsible for educating their peers about their social and cultural capital, particularly their familial capital. They effectively bridge their peers' worldviews and the lived experiences of growing up in a marginalized community. This creates a twofold disadvantage: it places an undue burden on these students and limits their opportunities to learn from the perspectives of their peers from high-income countries.

Natalia's experience exemplifies this challenge. Throughout her academic career, she has felt obligated to educate her peers about her cultural background, often in a one-sided manner. She

recounted instances where faculty asked her to explain communal cultures or the causes of infrastructure disparities in her home country. While these requests aimed to incorporate CCW into the curriculum, they burdened her disproportionately from her peers. She expressed:

> *Oftentimes these programs are putting the emphasis on people of color to bring the knowledge and the experience into the classroom and not the other way around...I shouldn't always have to be the one filling in the gaps.*

This lack of reciprocity hindered Natalia's educational experience. She desired a more equitable exchange of knowledge, noting:

> *There are experiences happening in our backyard in* [this city] *that can also be brought into the classroom...Why don't you ask some* [other] *kids what happens in their community?*

This absence of mutual learning meant she missed out on valuable insights about infrastructure disparities in the US and the perspectives of her American peers, knowledge directly relevant to her future work in HE.

This one-sided flow of knowledge reinforces a problematic power dynamic often present in HE programs, where LMICs are positioned as subjects of study. In contrast, high-income communities are positioned as the "experts" that study those subjects. This dynamic, rooted in colonial legacies, can limit learning opportunities for LMIC-tied students.

Beyond the burden of unilateral sharing, LMIC-tied students can find themselves disproportionately relying on their linguistic capital to navigate sensitive conversations and ensure

the emotional ease of their peers. This can involve significant emotional labor, as Stacy's experience illustrates:

> [When] *talking to somebody who hasn't critically thought about development…*[it feels] *very similar to when…my White family members… forget that I have an Asian experience…and I catch* [the problematic things they say] *and say, "Hey, maybe don't phrase it that way."* [This process] *hurts a lot…*[my family] *says stuff like…"If my intentions are good, why was* [what I said] *bad?" And* [I have to explain], *"I understand that you're not a bad person and that there's no malice here."*

While Stacy's efforts to bridge cultural divides are commendable, they highlight the emotional toll this responsibility can take.

Despite these challenges, this research also found that this disproportionate responsibility and the learning disadvantage can be mitigated when students and faculty from all backgrounds are encouraged to connect their experiences and values to HE issues. This fosters a co-enriched understanding of HE, drawing on diverse cultural and social capital.

Stephanie's experience provides a compelling example. Her thesis explored the influence of US car technology development on infrastructure in LMICs. She effectively integrated her resistance capital, drawing on her observations about the global influence of US culture on marginalized communities. She reflected, *"In* [my country], *we have a very car-centric culture because…we copied from the U.S...Ideas of development from one country can shape another...Because the U.S. road infrastructure changes how other countries perceive themselves as being developed."*

Critically, Stephanie's understanding was enriched through dialogues with her peers who had lived experience with US car culture. These conversations challenged her assumptions about sustainable

transportation and prompted her to consider issues like disabilities and weight bias in car technology development. She stated, "*I had the naive assumption that if everybody could bike everywhere, then everybody would be healthier...It took me time to learn about other intersections...*[for instance] *I'm working on really internalizing what fat bias is like and how weight stigma impacts people's health."*

While Stephanie functioned as a cultural bridge to her childhood, the burden was lessened by the reciprocal exchange of knowledge. Her peers connected her to valuable resources and insights, particularly one peer studying disability issues in the US, streamlining her research process and enhancing her learning and growth.

Marcela's experience further highlights the power of reciprocal exchange of capital. In classroom and informal discussions with her peers, she shared insights from her familial capital, specifically her experiences navigating privilege and power dynamics during HE efforts in her home country. She reflected, *"I've tried to learn much more about how my identity...impacts different power dynamics. In the U.S., I'm a minority; in* [my own country], *I'm the elite...Even if you're coming* [to partner communities] *with good intentions, there's never a balance of power."*

Through dialogue, Marcela also expanded her worldview by learning how her peers' experience of privilege and marginalization affected their humanitarian aspirations and work. She explained;

> *Almost everyone is American...But I find it really interesting how, as Americans, they reconcile all these social justice issues...and how those either reflect or contrast with mine when we talk about privilege. ... It's not just the fact that someone worked in Kenya for five years...It's that they were raised on the West Coast to a middle-class family. And then, that combined with their experience in Kenya, is really interesting to*

me… It's always a great conversation because people are very aware of their privilege and are open to discussing it and challenging it.

This highlights that meaningful exchanges can occur even when peers do not share the same social identities as LMIC-tied students. This was possible, as Marcela explained, because her peers were capable of introspection and open to having their perspectives challenged.

When HE programs foster an environment where students and faculty from all backgrounds are encouraged to share their experiences and perspectives, a more equitable and enriching learning experience emerges for everyone involved.

Institutional Support for Cross-Cultural and Multilingual Collaboration

This research found that LMIC-tied students can feel strained when they become important cultural and linguistic bridges to partner communities in HE projects. While they use their capital to make projects more relevant, locally desired, and co-created, this process can put them at a disadvantage. They must invest increased labor and time into projects, which often go unrecognized and unsupported by their institutions.

For instance, Marcela felt that her HE graduate program lacked sufficient resources for students working with diverse communities and underestimated the complexities of cross-cultural collaboration. Consequently, early in her graduate program, Marcela, fluent in both English and Spanish, took on the responsibility of establishing a weekly tutoring session for her peers to practice Spanish and offered guidance as they navigated HE experientials across language barriers. While Marcela was passionate about this, the increased time and labor she put into this exchange were on top of her standard classroom work, unpaid, and largely unsupported. She felt her HE program did not support language learning enough, stating:

> *I think language learning is genuinely such a big part of* [HE] *work because language is literally the way we think and builds our world and perspective. I do think that* [my HE] *center should support* [cross-cultural/linguistic] *work more.*

Furthermore, Marcela felt misunderstood by her institution, which did not understand the complexities of working with non-English speaking communities. Consequently, the institutionally supported training her program provided for students was insufficient. She stated:

> *I know a lot of students take up* [online language] *classes, which is great. But, for example, these discussions I have with them about language...they are about what the appropriate methods are to work better with communities over language barriers...there are tools and best practices for this kind of work.*

Similarly, Angelica discussed the substantial workload of improving cross-linguistic and cultural exchange in HE programs. Angelica put substantial work into making the materials of her thesis culturally and linguistically relevant in the US and the Latin American country she collected data from, including interview guides, consent forms, theses, journals, presentations, and dissemination documents. For instance, she described her plan to write her thesis in Spanish and then translate it, expecting it to take multiple days of work, stating:

> *It's the dialogue between English and Spanish, which is hard…I have to shuffle everything...It's a lot of translation work.*

The substantial additional effort Angelica and Marcela had to invest in making HE experientials collaborative and accessible to non-English speaking communities points to a paradigm in the HE field. Here, socially dominant institutions, while increasingly open to multilingual and cross-

cultural collaborations, can remain largely unaware of the considerable workload and nuances of translation work. This lack of awareness leads to inadequate structures and compensation mechanisms to support these efforts.

This burden can be mitigated through an institutional shift where bridging cultures and languages is recognized as a responsibility of HE in general and is institutionally supported through funding, translation tools, faculty verbal support, and accolades.

This shift is apparent in Marcela's interview a few years into her HE program, where she talks about working on a committee for a speaker series at her program to enable non-English speaking HE practitioners to present through translation services. She described this experience as her "favorite part of her graduate career," stating:

> *We got funding this year for translation…I'm the organizer, with a couple of others…While this takes a lot of time…everyone is so eager to try something new, supportive, and they trust me to do translations and to hire a professional translator.*

Marcela's HE program, which took responsibility for improving cross-linguistic exchange, mitigates her burden. She is still utilizing her capital to translate specific presentations, identify the resources needed to make a multilingual speaker series successful, and remain motivated to invest time and resources into creating this space. However, she now has verbal support, monetary resources to hire professional translators, and a formal conference role in translation services that she can leverage for future career opportunities.

Similarly, Ali developed his linguistic capital through learning his parents' native language, stating:

> [Learning my parents' native language] *has been a big confidence boost for me to be able to get a strong command of other languages*

In his thesis, he is leveraging this capital to continue learning languages to gather more relevant data and have a deeper collaboration with his partner community. His burden in this process is mitigated through institutional support. Specifically, Ali's university offers a curriculum in language learning and allows him to take classes in this program for credit toward his PhD. He describes how these resources allow him to keep building upon his linguistic capital, stating:

> [My university] *has a lot of foreign language courses…*[and] *I have the resources I need to keep learning* [the language of the country I am doing my thesis in]…*And I want to learn more languages because there are so many languages here in the north* [of this country].

Furthermore, he reflects on the support he has from his advisors to spend time and resources on language learning, saying:

> *My faculty advisors are super supportive…it's…reassuring to have people…telling you your opinion...*[has] *weight and that they trust you.*

These examples demonstrate how institutional ownership in language and cultural bridging can alleviate the burden on individual students while also promoting more equitable and effective collaborations with partner communities

Expanding Access to Knowledge and Social Networks of Marginalized Communities

Finally, this research found that LMIC-tied students may have limited access to a culturally responsive curriculum, professional networks, and philosophies outside the Eurocentric paradigm within the HE field. This lack of access can be a disadvantage, hindering their ability to build upon their CCW and further develop existing social networks, community connections, and cultural knowledge valuable to their HE careers.

For instance, Emmanuel described a situation where he wasn't receiving relevant knowledge and resources for his career goals. In particular, as part of his familial and resistance capital, Emmanuel had valuable knowledge of the process and importance of creating equitable relationships with community partners in HE work, which he developed from his experience working as an HE practitioner in an LMIC. His peers could learn from his experience in various classroom discussions. He stated:

> *There are power dynamics* [in] *a Western researcher coming to work in* [my country], *for example...In my community appraisal class...we talked a bit about that.*

However, Emmanuel was left without culturally relevant lessons for his own experiences:

> *You assume that because I'm from* [this country], *I am best placed to work there, which is true to some extent. But then even in my case, I've lived in the city most of my life, graduated in engineering, driving in this big 4x4 car coming into town...have the money...this is still something I'm thinking about...I don't think I've had so many conversations* [in school about this].

While Emmanuel used his capital to inform discussions on mitigating power dynamics, the discussions centered around the power dynamics of White American practitioners in LMICs. Thus, despite Emmanuel using his CCW to enrich his peers' education, he was left to grapple with important questions about power dynamics in his future career alone. This example highlights how HE programs may not adequately address the needs of LMIC-tied students even when they acknowledge the importance of diverse perspectives.

Other students reflected that while teaching their peers their unique philosophies around international development, childhood experiences, and community history, they found it challenging to build upon that non-Eurocentric familial, linguistic, and resistance capital. Angelica reflected that the lack of literature from non-Eurocentric sources was one of her largest complaints about her coursework, stating:

> *I think if we…have…students interested in Latin America...we should build more knowledge on, at least* [the] *history, culture, the structure* [and] *political dynamics* [of Latin America]

Marcela similarly expressed frustration with the Eurocentric focus of the curriculum, stating:

> *I'm trying to individually educate myself on the history* [of international development] *through Latin American eyes. ... I'm not getting* [that perspective] *at all from the program, not even the resources to* [educate myself].

These experiences highlight a potential pitfall in HE programs: a limited extent to which they value non-Eurocentric social and cultural capital. While HE programs may seek easily digestible insights from LMIC communities, they may not structurally incorporate resources and systems to develop students' CCW further.

However, this research also found that this educational disadvantage could be mitigated when students had avenues to integrate social networks, contextual issues, community experts, and scholars to whom they had regional, racial, or familial ties into their HE education.

For example, Angelica conducted her thesis research in her home region, utilizing a non-profit partner she had worked with in the past and involving community participants from her hometown in data collection. In this effort, her social and linguistic capital allowed her to have more fruitful data collection efforts. She explained:

> *I will say* [my past experiences] *definitely helped me. The connections* [to people I have] *there and* [overcoming] *the language barrier, then my knowledge about public transportation, what to expect...I was prepared to go to the field....because ... I have worked in very similar conditions for my volunteering activities.*

Furthermore, having a thesis that integrated community partners to which she had regional ties meant Angelica's advisor had a mutual interest in helping her develop her non-Eurocentric capital. He helped her connect with regional experts and literature on the specific HE issue she was passionate about. Angelica notes:

> *My advisor consistently provides valuable resources, including literature recommendations and introductions to key contacts in the field.*

On top of this, she was connected to a professional network of scholars on the topic and region she was passionate about by presenting her work at a relevant academic conference. She reflected on the value of this experience, stating:

> *It was like one of the best experiences I had because…the focus…*[of the conference was on] *Latin America. So there were* [both] *a lot of* [fellow] *researchers, in* [their] *masters...And ... experts coming from different countries…with* [varying] *perspectives and from different fields of expertise…this is the most updated information about* [the HE issue I am passionate about].

Angelica's regionally relevant thesis helped her expand her professional network in the region she wanted to work in someday and address the gap in relevant resources she received in her coursework.

Through social networks that students have regional, racial, or familial ties to in their internships, they overcame some disadvantages of being in predominantly white educational spaces. For instance, Tao's fieldwork in Latin America helped him improve his linguistic capital and strengthen his aspirational capital through an invigorated desire to work in Latin America. He stated:

> *I just got reminded of how much I want to live abroad. Spending two months* [researching] *in* [Latin America]…*One of the biggest jumps for me was being able to communicate in Spanish and feel comfortable…*[to] *communicate all my ideas, even if they're complex and nuanced.*

Similarly, Marcela reflected on how being in an internship with many other women of color helped her see her identity in STEM as "expected" rather than an exception. This experience fostered her aspirational capital by legitimizing her presence as a woman of color in STEM. She explained:

> *I'm not used to seeing ... for example, three Black women who were all working at a fusion reactor. And it wasn't just one who was championing this work for Black women*

in a room of White people. … I think it legitimizes it to an extent their [presence in that] *community and in that context…It's not an exception* [that a person of color is in STEM].

These examples demonstrate how integrating external knowledge and networks of marginalized communities into the curriculum can create valuable opportunities for LMIC-tied students to build upon their CCW. By fostering connections with community experts, scholars, and resources relevant to students' backgrounds, HE programs can also challenge the dominance of Eurocentric knowledge.

Discussion

This research explores the relationship between the valuable community cultural wealth (CCW) of LMIC-tied students and the burdens they experience when sharing this capital in humanitarian engineering (HE) graduate programs. Our findings reveal a tension: while HE programs increasingly seek to diversify and incorporate the perspectives of LMIC communities, sharing CCW can often lead to disadvantages and emotional labor for these students. Specifically, our analysis identified three key themes that illuminate this tension.

First, LMIC-tied students often bear the burden of educating their peers, exemplified by Natalia's experience of constantly 'filling in the gaps' on concepts like communal cultures in her home country. The emotional labor involved in this imbalance mirrors how simply increasing the number of students of color in an academic program makes them shoulder the responsibility for institutional change (Love, 2023) and positions LMICs as study subjects rather than equal partners in knowledge creation.

Second, LMIC-tied students can feel burdened when serving as important cultural and linguistic bridges to partner communities. While their linguistic capital is essential, this can lead to an increased workload and a lack of institutional support, mirroring the undervaluation experienced by LMIC practitioners capable of linguistic and cultural translation in the HE industry (Peace Direct et al., 2021). This suggests that professional inequities, including undervalued cultural expertise and unpaid labor, extend into the educational context.

Finally, HE programs may not adequately provide access to a culturally responsive curriculum, professional networks, and non-Eurocentric philosophies. This limits LMIC-tied students' ability to build upon their existing knowledge. Angelica and Marcela's frustration with the Eurocentric curriculum underscores this limitation. This Eurocentric focus reflects the concerns of LMIC practitioners, who report that their knowledge systems are often devalued (Peace Direct et al., 2021).

However, our findings also point to institutional approaches that can mitigate these burdens and create more supportive learning experiences. Fostering reciprocal knowledge exchange with peers and faculty aids LMIC-tied students in learning from diverse social and cultural capital forms. Sharing relevant childhood experiences and values and connecting them to HE issues fosters the co-creation of knowledge amongst students and deeper learning. Stephanie's research on the influence of US car culture on LMIC countries, enriched by peer dialogues on their lived experience in US car culture, exemplifies this.

Next, to avoid overburdening LMIC-tied students, institutions can take ownership in language and cultural bridging. This includes providing resources, support services and demonstrating a commitment to language exchange, which empowers LMIC-tied students and may be considered

a holistic need of these marginalized students, something scholars say is imperative to prioritize in diversifying schools (Carter, 2004).

Finally, integrating external knowledge and networks into the curriculum relevant to students' racial, cultural, and regional ties, such as community experts, allows LMIC-tied students to build upon their CCW. This approach taps into a wealth of knowledge beyond traditional academic boundaries and reflects the practice of community engagement seen in HBCUs (Upton & Tanenbaum, 2014).

These findings have significant implications for HE programs. To truly diversify and decolonize the field, institutions must move beyond simply recruiting LMIC-tied students and actively work to create inclusive learning environments that value and support their CCW. This requires critically examining curriculum, pedagogy, institutional policies, and experiential learning opportunities. It also necessitates a commitment to challenging Eurocentrism and fostering reciprocal efforts to incorporate CCW into HE education across the HE graduate community.

Limitations

This study has limitations, including a small sample size and a focus on programs with explicit missions to serve marginalized communities. Future research could explore LMIC-tied student experiences in a broader range of engineering programs and examine their long-term career trajectories. Further research is needed to explore the experiences of students of color without significant ties to LMICs in HE, as those students remain grossly underrepresented in HE, including only one in the broader study this research was conducted under.

It is important to acknowledge a demographic limitation of this study: participants with ties to LMICs who are enrolled in US graduate programs often represent privileged socioeconomic

backgrounds within their home countries. Their experiences may not reflect those of individuals from lower socioeconomic backgrounds in these same countries, who face additional barriers to accessing international education. Rather than positioning these students as representative of entire LMIC populations, this study examines the specific experiences of those who have successfully navigated educational pathways to US graduate programs while maintaining meaningful connections to their LMIC communities of origin. Future research should explore more diverse socioeconomic backgrounds within LMIC populations and how different levels of privilege affect experiences in humanitarian engineering education

Conclusion

This research underscores the complexities of diversifying humanitarian engineering (HE) graduate programs. While incorporating the social and cultural capital of LMIC-tied students is crucial for decolonizing the field and fostering more effective and ethical practices, LMIC-tied students expressed instances of burden in this process with increased time and labor they were asked to contribute at the expense of their educational outcomes. In order to value the cultural wealth and assets brought to the program by these students, HE programs need to actively cultivate learning environments where bringing in diverse worldviews, skill sets, and perspectives is not only valued but a shared responsibility among the graduate school community. This involves fostering reciprocal learning and dialogue on cultural capital across students, providing institutional support for linguistic and cultural bridging with partner communities, and integrating external knowledge and networks from marginalized communities into the curriculum. By addressing the burdens identified in this study and implementing the suggested institutional practices, HE programs can create a more equitable and enriching educational experience for all

students, ultimately contributing to a more equitable and effective humanitarian engineering sector.

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Chapter 6. Conclusion and Contributions

In this dissertation, I investigated the educational development of humanitarian engineering (HE) students across multiple graduate programs, examining how student career aspirations and social justice capabilities transformed through their education. Through longitudinal interviews with 46 students across seven programs. I examined how different learning experiences shape students' development, including academic coursework, experiential projects, fieldwork, institutional norms, and policies. Within this, I explored how students navigate the complex dynamics of questioning their career aspirations, particularly as the HE field undergoes fundamental transformation around decolonization and anti-racism.

This dissertation advances theoretical understanding in several areas: how career outcome expectations and self-efficacy trajectories evolve throughout HE graduate education, how students develop social justice self-efficacy across multiple domains of activism, how educational environments can nurture resistance to systemic inequality while maintaining technical rigor, and how diverse forms of cultural capital can enrich engineering education when adequately supported. Each chapter builds upon previous findings - from identifying how students question their career aspirations (Chapter 2) to examining the educational practices that shape their capacity to identify and resist inequality structures in the HE field (Chapter 3), to tracking their self-efficacy activism development over time (Chapter 4), and finally to understanding how to create genuinely inclusive learning environments that benefit from diverse perspectives (Chapter 5).

Practically, this research provides concrete recommendations for HE programs to better support their students' development into effective agents of social change. The findings inform how programs can help students navigate career questioning while maintaining their social impact aspirations, structure learning experiences to nurture critical consciousness alongside technical

capabilities, sequence educational components to optimize self-efficacy development and create institutional practices that support rather than burden students from diverse backgrounds. Table 6-1 summarizes these theoretical and practical contributions across chapters.

Table 6-1 Summary of Research Contributions

Research Questions	Theoretical Contributions	Practical Contributions
Chapter 2: How are graduate students questioning their HE career expectations throughout HE graduate programs? How are HE's academic and experiential learning experiences prompting students to ask these career expectations?	This study advances understanding of how learning experiences shape career expectations in HE education. It reveals how different categories of learning experiences collectively influence students' career trajectories, with academic learning primarily affecting students through vicarious experiences of failed projects and verbal persuasion about systematic barriers. In contrast, experiential learning impacts students through personal mastery failures and emotional distress.	This research provides recommendations for how HE programs can enhance their support of students' career development. Findings suggest programs should balance critical analysis with successful examples, enhance support during experiential learning, and expand preparation for work-life challenges in HE careers.
Chapter 3: Which HE educational practices either inhibit or facilitate students' critique of social oppression and motivation for social justice?	This study expands the Transformational Resistance Framework beyond its traditional application with marginalized students to examine how learning environments can nurture resistance behaviors in students who may hold social privileges over the structures they resist. It reveals how interest convergence and whiteness as property manifest in educational settings, limiting progress in HE education.	The findings identify specific practices that program administrators and faculty can work to identify and challenge within their educational environments. It provides concrete recommendations for practices that nurture students' capacity to challenge systemic inequality, including meaningful engagement with lived experiences of disparities, integration of multidisciplinary perspectives, and robust historical education.
Chapter 4: How does Social Justice Self-Efficacy (SJSE) change over time for students in HE programs?	This study reveals how different forms of SJSE interact and develop synergistically through combined theoretical and experiential learning. It demonstrates how temporary decreases in SJSE can represent productive developmental phases rather than failures of engagement, advancing an understanding of how self-efficacy influences career development in HE contexts.	Programs should anticipate and provide structured support for students through the progression of SJSE development across semesters. Findings highlight the importance of intentionally sequencing theoretical and experiential learning opportunities and emphasizing the development of interpersonal SJSE.

Chapter 5: What institutional practices create supportive learning environments for LMIC-tied students?	This study expands the application of Community Cultural Wealth beyond identifying assets that marginalized students possess to examining how institutional practices can either support or burden students when sharing this capital. It reveals how challenges LMIC practitioners face in humanitarian work are reproduced in educational settings.	The findings reveal concrete opportunities for programs to create more equitable learning environments that benefit from LMIC-tied students' perspectives while protecting their educational development. This includes implementing an exchange of social and cultural capital between all students, expanding access to non-Eurocentric knowledge, and Institutional support to incorporate community perspectives into HE.

Chapter 2

In Chapter 2, I investigated how graduate students in HE programs question their career expectations and goals. Using the complete dataset of interviews conducted with 46 students across seven HE graduate programs, I analyzed how students reevaluated their career aspirations using Social Cognitive Career Theory as a framework (Bandura, 1997; Lent et al., 1994). The findings revealed three main themes of questioning: the HE sector's ability to create meaningful societal impact (98% of students), students' capacity to make an impact (96%), and work-life balance and career benefits in HE (87%). In academic settings, students were exposed to extensive examples of failed HE initiatives, including projects designed without community input, implemented unused infrastructure, and interventions that caused social tension or undermined local economies. They learned about organizations whose sustainability missions were forms of greenwashing and studied cases where international aid efforts perpetuated inequality. Meanwhile, their experiential learning confronted them with significant challenges - students struggled with motivating community participation, faced difficulties accessing sensitive data, and grappled with feelings of isolation when working across cultural and linguistic barriers. Many experienced emotional distresses from witnessing global inequality while questioning whether their research would benefit participating communities. The study found that while HE education develops students' critical understanding of injustice, it may simultaneously diminish their confidence in addressing environmental and social equity through engineering careers. This research advances our understanding of how learning experiences in HE graduate programs influence students' career expectations. It also highlights opportunities to support students' social impact aspirations better while developing their critical awareness.

Chapter 2: Theoretical Contributions

Chapter 2 advances our understanding of how learning experiences in graduate education influence career expectations and goals in HE. While prior research has shown that undergraduate students involved in HE activities may question their career aspirations (Litchfield & Javernick-Will, 2017; Smith, 2019), this study deepens our knowledge by systematically analyzing the types of learning experiences that prompt this questioning at the graduate level.

By using Social Cognitive Career Theory (SCCT), this research reveals how different categories of learning experiences - mastery, vicarious, verbal persuasion, and emotional - collectively shape students' career expectations. The findings demonstrate that academic learning primarily influences students through vicarious experiences of failed projects and verbal persuasion about systematic barriers. In contrast, experiential learning affects students through personal mastery failures and emotional distress.

The study also contributes to engineering education literature by showing how graduate HE programs differ from traditional engineering education in developing students' critical awareness of systemic injustice. While previous scholarship found that engineering education often overlooks systemic injustices when teaching about engineering failures (Schneider et al., 2009), this research demonstrates how HE graduate education actively engages students in critiquing colonial legacies and harmful practices in engineering. However, this heightened critical awareness appears to simultaneously diminish students' confidence in achieving social impact through engineering careers – an understudied dynamic in engineering education literature.

Chapter 2: Practical Contributions

Chapter 2 recommends several ways HE graduate programs may enhance their support of students' career development while maintaining dedication to social and environmental equity. The findings suggest programs may benefit from balancing critical analysis of failed projects with examples of successful, ethical HE work. While examining project failures and systematic injustices remains valuable, programs could consider providing additional frameworks and models for effective practice.

This research also identifies opportunities to enhance support during experiential learning. Programs may consider offering structured guidance as students navigate complex project trade-offs. For example, students struggled to balance community participation with research timelines, weighing environmental impact against economic development, and managing resource constraints while ensuring project sustainability. Programs could provide frameworks for making these decisions while maintaining ethical practices. Students may also benefit from additional tools and strategies for advocating organizational change, such as guidance on initiating conversations about social justice in engineering firms and approaches for influencing company culture and policy from entry-level positions.

The findings suggest potential value in expanding preparation for work-life challenges in HE careers. Programs could incorporate more discussions and examples of maintaining work-life boundaries while working in emotionally demanding contexts with marginalized communities. Students may benefit from hearing how practitioners manage extended travel, build relationships across cultural barriers, and maintain connections with home communities. Programs could also address financial planning, given the economic trade-offs of social impact work and strategies for building a professional community despite geographic mobility. This enhanced preparation may

be particularly valuable as students encounter these challenges primarily through stressful personal experiences rather than constructive academic discourse.

Chapter 3

In Chapter 3, I investigated how HE education influences students' capacity to identify, resist, and dismantle inequitable structures in the HE and broader engineering fields. Once again, using the complete dataset of interviews conducted with 46 students, I analyzed how educational practices inhibited or facilitated students' resistance behaviors using the Transformational Resistance Framework (Hannegan-Martinez et al., 2022; Solórzano & Bernal, 2001). Findings demonstrated that HE programs can inadvertently normalize compliance with inequality through their structures and policies. However, they can also create learning environments that nurture students' capacity to identify and transform inequitable structures.

Three practices that hindered students' resistance emerged: prioritizing individual and institutional goals over community well-being (such as when students prioritized research outputs over community workshops), neglecting ongoing impact on partner communities (exemplified by students avoiding accountability for long-term project sustainability), and relying on personal reflection rather than expert guidance for understanding social justice concepts (as seen when students spent hours attempting to self-define concepts like *"co-creation"* without consulting affected communities or scholars). Conversely, three practices facilitated students' resistance: integrating relevant experiential knowledge of marginalization (through meaningful engagement with firsthand accounts from marginalized communities via conversations, readings, and personal experiences), embracing multidisciplinary perspectives on social justice (by learning frameworks and vocabulary from fields like Indigenous Studies), and engaging with historical education on

oppressive structures (through studying how engineering and international development have historically perpetuated inequality).

Chapter 3: Theoretical Contributions

This study expands the Transformational Resistance Framework beyond its traditional application with marginalized students to examine how learning environments can nurture resistance behaviors in students who may hold social privileges over the structures they resist. Consequently, a vital contribution of this research for educational scholarship is utilizing TRF alongside CRT scholarship on social privilege to understand how learning experiences can nurture the activist capacity of students who hold intersecting privileges (D. A. Bell, 1980; Tanner, 2018).

Second, through this expanded application, we found that HE learning environments can normalize practices that parallel patterns seen in socially dominant groups since the civil rights movement. These practices inhibit students from engaging in resistance behaviors. For instance, interest convergence manifests in educational settings, revealing how HE structures (policies, curriculum, norms) reward students to prioritize the needs of marginalized groups only when they align with university or student interests—similar to how U.S. civil rights progress occurred primarily when it served dominant groups' interests (D. A. Bell, 1980). This appeared when students prioritized completing experiential assignments and justifying project goals over addressing concerning impacts on partner communities and viewed speaking up about unethical practices in internships as an *"occupational hazard"* that could harm their career prospects.

Moreover, the concept of "whiteness as property" illuminates how engineering education can normalize students' perceived right to ignore marginalized communities' lived experiences, just as white parents historically defended their privilege to maintain segregated schools (Harris, 1993).

Students often view disconnection from community impact as an acceptable right, manifesting in various ways: students attempting to suppress their emotional distress and accountability when their team potentially put a community partner at risk for harm or justifying their ignorance of long-term project sustainability by seeing it as outside their role as an engineer. This habitual practice of irresponsibility between HE efforts and marginalized communities' ongoing experiences demonstrates how educational environments can reinforce students' perceived right to avoid accountability for their impact.

Chapter 3: Practical Contributions

First, as described above through the lens of interest convergence and whiteness as property, this chapter identifies specific practices that program administrators and faculty can work to identify and challenge within their educational environments. For example, programs could examine how their HE projects' norms and grading policies may enable students to exercise their perceived right to ignore marginalized communities' experiences and avoid responsibility for project outcomes. Instead of relying on students to individually overcome ingrained US cultural norms that deprioritize marginalized communities' needs, HE programs should create structural changes. Programs can develop evaluation metrics and accountability systems that explicitly align university and student incentives with ongoing community well-being. For example, this could include making community impact central to course grading criteria, requiring evidence of sustained community benefit beyond project completion, and establishing long-term communication channels with partner communities.

Second, this research provides concrete recommendations for practices that nurture students' capacity to identify, resist, and challenge the systemic inequality around them, aligning with existing scholarship on transformative education. Programs are recommended to:

Create opportunities for meaningful engagement with firsthand accounts from marginalized communities through guest speakers, readings, and structured dialogue with community partners. This aligns with CRT scholars' emphasis on counter-storytelling as a powerful tool for understanding oppression (Hubain et al., 2016). For example, students in this study benefited from conversations with engineers from LMICs about infrastructure disparities, engagement with memoirs and social media from marginalized communities, and learning from faculty, practitioners, and mentors with firsthand experience of marginalization.

Integrate multidisciplinary perspectives on social into coursework. This supports culturally sustaining pedagogy that values linguistic, literacy, and cultural pluralism (Paris & Alin, 2017). For example, students in this study benefited from courses in moral philosophy, women and gender studies, environmental ethics, anthropology, and various ethnic studies that provided them with frameworks and vocabulary to better understand and challenge inequitable practices in HE.

Include robust historical education on how engineering and international development have perpetuated inequality through required readings, case studies, and guided discussions. For example, students in this study benefited from studying various historical inequitable structures, including global debt, extractive economics, repercussions of colonialism, and environmental devastation, through books like *The Open Veins of Latin America* and *The Divide: A Brief Guide to Global Inequality*.

Chapter 4

In Chapter 4, I investigated how social justice self-efficacy (SJSE) develops during students' first year in HE programs. Using a focused subset of 88 interviews conducted with 22 students who began their programs in Fall 2021 and completed all four interviews over their first three semesters,

I analyzed changes in students' perceived ability to engage in social justice activism. Through the SJSE framework (M. J. Miller et al., 2009), I tracked SJSE development across four dimensions: personal (examining one's own biases and worldview), interpersonal (challenging others' biases and communicating across cultural differences), community (improving conditions in specific marginalized communities), and institutional (influencing policies and norms of organizations to be more just). The findings reveal a complex developmental progression through three distinct phases. During the first semester's critical exposure phase, coursework dramatically increased students' personal SJSE as they encountered diverse perspectives and critical frameworks. However, this heightened awareness often temporarily decreased their community and institutional SJSE as they grappled with systemic critiques of development work and questioned their ability to create meaningful change. In the second semester's integration phase, students began rebuilding their SJSE through practical applications, mainly through thesis development and project-based work that helped them identify specific approaches to social impact while maintaining their critical awareness. Summer fieldwork then served as an intense testing ground where students experienced both significant gains and setbacks as they confronted the challenges of applying their developing SJSE in real-world contexts. For instance, some students discovered that strong interpersonal SJSE navigating cross-cultural communication significantly enhanced their ability to create community-level impact. In contrast, others found their community SJSE challenged when confronting cultural barriers to technology adoption. These experiences shaped students' career trajectories in various ways. For example, some pivoted toward alternative pathways like domestic environmental justice work, where they felt better positioned to create change. In contrast, others developed specific strategies to work within existing institutions or create new organizational approaches to address the systemic challenges they had identified.

Chapter 4: Theoretical Contributions

This study makes several significant theoretical contributions to understanding SJSE development in HE education. First, while previous research has noted that HE students can experience frustration and disengagement when confronting complex ethical dilemmas (Niles et al., 2018), this study reveals that temporary decreases in SJSE can represent a productive phase of development. The first semester's dramatic gains in personal SJSE and decreases in community and institutional SJSE suggest that students aren't failing to engage with systemic critiques but are developing a deeper critical consciousness that temporarily shakes their confidence in creating change.

Building on Litchfield and Javernick-Will's (2017) finding that moments of disillusionment can also serve as opportunities where practitioners figure out how to pivot their approach, our study reveals how these apparent setbacks in SJSE often catalyze productive transformations in students' HE trajectories. Rather than viewing decreased SJSE as purely negative outcomes or indicators of failed engagement with social justice concepts, we found these experiences often represented crucial developmental phases where students redirected their aspirations toward contexts where they felt better positioned to create meaningful change. This suggests that HE programs are successfully fostering critical awareness. However, it initially manifests as decreased confidence rather than immediate empowerment, and this temporary decrease can serve as a foundation for more strategic and sustainable approaches to creating social change.

Second, this study deepens our understanding of how different forms of SJSE interact and develop synergistically through combined theoretical and experiential learning. While previous research has established that HE programs often include coursework and project-based components (Smith et al., 2020), our findings reveal how these elements work together to rebuild students' SJSE after

initial critical exposure. The second semester showed how theoretical knowledge gained from coursework could be productively integrated into thesis development and project work, helping students identify specific approaches to create social impact while maintaining their critical awareness. This builds on existing literature about the importance of project-based learning in HE education (Birzer & Hamilton, 2019; Passino, 2009) by illuminating the temporal and developmental relationships between theoretical learning and practical application.

Chapter 4: Practical Contributions

The findings from this study reveal several important implications for HE graduate education. First, programs should anticipate and provide structured support for students through the progression of SJSE development across semesters. Understanding that first-semester coursework often produces a decrease in community and institutional SJSE, programs can proactively help students navigate this challenging period. For instance, faculty could explicitly frame these initial struggles with systemic critiques as a common and valuable part of developing critical consciousness rather than letting students interpret decreased confidence as a personal failure or program ineffectiveness.

Second, our findings highlight the importance of intentionally sequencing and integrating theoretical and experiential learning opportunities. The study revealed that while first-semester theoretical critiques often decreased students' SJSE, second-semester project work helped rebuild their confidence through practical applications. Programs could leverage this pattern by ensuring students have structured opportunities to apply their growing critical awareness through thesis development, research projects, or other experiential learning during their second semester. Additionally, programs might consider incorporating more frequent, smaller-scale practical

applications during first-semester coursework to help students maintain a sense of agency while developing their critical consciousness.

Third, programs should emphasize developing students' interpersonal SJSE alongside technical and theoretical knowledge. Our findings showed that confidence in cross-cultural communication and professional advocacy significantly impacted students' ability to create community-level change. Programs could incorporate more structured opportunities to practice challenging others' biases, communicating across cultural differences, and advocating for social justice within professional contexts.

Chapter 5

In Chapter 5, I investigated how to create supportive learning environments for students with familial ties to low- and middle-income countries (LMICs) in HE programs. Using a focused subset of 69 interviews conducted with 19 LMIC-tied students across six HE graduate programs, I analyzed how students experienced sharing their cultural and social capital using Yosso's Community Cultural Wealth framework (T. Yosso, 2005). The interviews explored how students' various forms of capital manifested and were received in their education, examining when these sharing experiences were either burdensome or supportive to their learning. The findings revealed three key themes about how these students experience sharing their capital in their education. First, LMIC-tied students often bore a disproportionate responsibility for educating their peers about their cultural background and experiences. Second, while these students effectively used their linguistic and cultural capital to bridge communication with partner communities, they often faced increased workloads and insufficient institutional support for these efforts. Finally, despite contributing valuable insights from their communities, these students had limited access to culturally relevant curricula and non-Eurocentric knowledge that could help them build upon their

existing cultural wealth. However, the research identified several institutional practices that could mitigate these challenges. The first practice involved fostering reciprocal knowledge exchange where all students and faculty were encouraged to connect their experiences and values to HE issues. The second practice centered on providing formal institutional support for cross-cultural and multilingual collaboration through funding for translation services, credit-bearing language courses, verbal support from faculty, and formal recognition of translation work in student roles and responsibilities. The third practice focused on expanding access to knowledge and networks from marginalized communities by integrating community experts and scholars into the curriculum, creating opportunities for research with regional partners, and connecting students to professional networks that align with their cultural and regional backgrounds.

Chapter 5: Theoretical Contributions

This study advances the understanding of how diverse forms of cultural capital are valued and burdened in educational environments in several ways. First, it expands the application of Community Cultural Wealth beyond identifying assets that marginalized students possess to examining how institutional practices can either support or burden students when sharing this capital. Consequently, a contribution of this research for educational scholarship is utilizing CCW alongside CRT scholarship on diversity initiatives to understand how learning environments can equitably incorporate diverse perspectives while protecting student wellbeing.

Second, through this application, we found how LMIC-tied students experience burdens that mirror historical patterns in both educational diversity efforts and humanitarian practice. The research reveals how universities' historical tendency to place diversity responsibilities on marginalized students continues in humanitarian engineering education. This appeared when students were expected to educate peers about their cultural backgrounds without receiving similar

learning opportunities themselves and when their linguistic expertise was utilized for translation without institutional support or compensation. This aligns with scholarship on educational institutions relying on marginalized students to shoulder the burden of diversifying education and expectations of educating peers about their cultures and experiences through tokenization (Delmont, 2006; hooks, 1994; Love, 2023).

Moreover, the research reveals how challenges faced by LMIC practitioners in humanitarian work are reproduced in educational settings. Just as practitioners report having their contextual expertise undervalued while being expected to serve as cultural bridges, LMIC-tied students face similar contradictions: their cultural knowledge is sought after, yet they lack access to a culturally relevant curriculum (Peace Direct et al., 2021). Their linguistic abilities are relied upon yet inadequately supported. This parallel between professional and educational burdens demonstrates how institutional practices can perpetuate patterns of inequitable labor even in programs explicitly trying to value diverse perspectives.

Chapter 5: Practical Contributions

Practically, Chapter 5's findings reveal concrete opportunities for HE programs to create more equitable and effective learning environments that benefit from LMIC-tied students' valuable perspectives while protecting their educational development. With this information, programs can design structures that more effectively support students' cultural and social capital contributions alongside their learning needs. For example, programs could ensure that opportunities to share cultural knowledge are balanced with intentional learning experiences where LMIC-tied students gain new perspectives from their peers and faculty about HE in various contexts. Amid increasing recognition of students' valuable linguistic and cultural expertise, programs could implement formal support structures like paid translation roles, course credit for language development, and

resources for cross-cultural project work rather than relying on informal, uncompensated student labor. Additionally, as programs seek to benefit from students' connections to marginalized communities, they could expand access to non-Eurocentric knowledge through intentionally incorporating scholars and practitioners from these communities into the curriculum, supporting research partnerships in students' home regions, and facilitating professional networking with experts sharing students' cultural backgrounds.

Crucially, these findings call for a fundamental shift in how programs view LMIC-tied students' educational experiences. HE stakeholders should be mindful not to unconsciously fall into the false deficit mindset of assuming these students should simply be grateful for access to U.S. HE education. Nor should we fall into the norm of using them as the avenue to diversify the learning environment for others without taking accountability for institutional changes needed to support this transition.

Cross Chapter Recommendations for Humanitarian Engineering Programs

This dissertation reveals several overarching practical recommendations that emerge across multiple studies, offering humanitarian engineering programs actionable guidance for preparing students as effective agents of social change.

A significant cross-cutting finding concerns how educational structures influence students' development. Chapters 2, 3, and 4 collectively demonstrate that humanitarian engineering programs would benefit from examining their institutional structures—including evaluation metrics, project timelines, and course sequencing—to ensure they align with social justice goals. The research indicates that current assessment approaches often reward completion of deliverables

over sustained community impact. Transforming these structures to explicitly value community well-being could help programs better support students' development as social change agents.

Another recurring recommendation across chapters relates to the strategic integration of critical analysis with practical application. Chapters 2 and 4 particularly highlight the importance of balancing theoretical critique with constructive examples and actionable frameworks. The findings suggest that while developing students' critical consciousness about systemic inequality is essential, this awareness must be paired with opportunities to apply this understanding through project-based learning. This balance helps students navigate the disillusionment that often accompanies deepening awareness of systemic barriers while maintaining confidence in their capacity to create meaningful change.

Chapters 3, 4, and 5 collectively emphasize the value of multidisciplinary perspectives in humanitarian engineering education. The research demonstrates that integrating frameworks from fields like ethnic studies, women and gender studies, and indigenous studies provides students with essential conceptual tools for understanding infrastructure disparities. These diverse perspectives help students develop more sophisticated analyses of power dynamics, cultural contexts, and historical legacies that shape humanitarian engineering practice. Programs would benefit from creating formal pathways for students to engage with these multidisciplinary perspectives throughout their education.

The importance of supporting students through emotional challenges emerges across Chapters 2, 4, and 5. The findings reveal that humanitarian engineering work involves significant emotional labor—whether witnessing global inequality, navigating cross-cultural relationships, or confronting limitations in creating change. Programs could better prepare students by

incorporating discussions about maintaining boundaries in emotionally demanding contexts, developing resilience during fieldwork experiences, and addressing practical concerns like work-life balance. These supports appear particularly crucial during transitional periods identified in Chapter 4, including the initial exposure to critical perspectives and first fieldwork experiences.

Chapters 3 and 5 highlight the need for reciprocal knowledge exchange where all participants—not just those from marginalized backgrounds—contribute their perspectives and learn from others. The research indicates that current approaches often place disproportionate responsibility on students from low and middle-income countries to educate their peers about cultural contexts. Programs would benefit from creating structured opportunities for all students to connect their backgrounds to humanitarian engineering issues, while providing institutional support for cross-cultural collaboration through translation resources and language education.

These cross-cutting recommendations, emerging from multiple studies within this dissertation, offer humanitarian engineering programs concrete approaches to better prepare a diverse generation of engineers equipped to address global infrastructure disparities through sustainable and equitable approaches.

Contributions to Engineering as a Discipline

This dissertation not only examines humanitarian engineering education but also contributes to broader conversations about reimagining engineering as a discipline. The findings across all four studies offer critical insights into how engineering itself—not just its humanitarian applications—can be transformed to better address systemic inequality and incorporate diverse knowledge systems.

Each chapter illuminates different aspects of how engineering's dominant paradigms can be challenged. Chapter 2 revealed how students critically question not just their individual career paths but the fundamental capacity of engineering to address social and environmental inequity—highlighting tensions between engineering's technical focus and the complex social, political, and historical contexts in which infrastructure disparities persist. Chapter 3 demonstrated how engineering practices that prioritize institutional goals and individual achievement over community well-being reinforce colonial dynamics, while practices that integrate experiential knowledge of marginalization and historical understanding of oppressive structures foster resistance to systemic inequality. Chapter 4 traced the development of students' confidence in creating social change, revealing how engineering education can support students through challenging periods of disillusionment to develop more sophisticated approaches to advocacy. Chapter 5 exposed how engineering education often burdens students from low and middle-income countries by extracting their cultural and social capital without providing adequate institutional support or access to non-Eurocentric knowledge systems.

Collectively, these findings challenge engineering's claims to neutrality and universality by demonstrating how dominant engineering practices often reinforce existing power structures. They reveal that engineering is not merely a technical discipline but one deeply embedded in social, political, and historical contexts—contexts that shape who participates in engineering, whose knowledge is valued, and which communities benefit from engineering work.

I acknowledge that this research operates within certain constraints of academic institutions. This dissertation was conducted within traditional university structures and focuses primarily on reforming existing engineering programs rather than creating entirely new models. Additionally, as Tuck and Yang (2012) remind us, truly decolonizing engineering would require more radical

transformations, including land repatriation and Indigenous sovereignty—goals that extend beyond educational reform.

Despite these limitations, this research suggests several pathways for more radical reimagining of engineering education and practice. First, engineering programs could move beyond merely diversifying their student bodies to fundamentally reshaping how engineering knowledge is produced and validated—incorporating community expertise, oral histories, and indigenous knowledge systems as legitimate engineering resources. Second, engineering curricula could be reconstructed around specific community needs and contexts rather than abstract technical competencies, embedding community members as co-educators with recognized expertise. Third, engineering institutions could establish new models of accountability to historically marginalized communities, creating structures for community governance in engineering research and education.

In conclusion, while this dissertation focuses on improving humanitarian engineering education, its contributions extend to reimagining engineering more broadly. By revealing how students develop capacity to question, resist, and transform engineering practices, this research contributes to ongoing efforts to create an engineering discipline that not only serves marginalized communities but is fundamentally shaped by their knowledge, needs, and aspirations.

Limitations and Future Work

The study's scope was bounded by several factors that should be considered when interpreting the findings. First, while the research included 46 students across seven humanitarian engineering programs, these programs were specifically selected based on their explicit missions to serve marginalized communities rather than representing the full spectrum of engineering education

programs. Important demographic facctors including gender, religious background, and socioeconomic status were not systematically analyzed. Furthermore, we did not evaluate the experiences of students of color without significant ties to LMICs, who remain significantly underrepresented in humanitarian engineering, with only one such participant in the study.

While the study captured students at various stages of their graduate programs, it did not follow most students from program entry through graduation to professional roles, limiting our understanding of how career expectations align with workplace realities and long-term professional trajectories. Additionally, the investigation of educational practices influencing students' career goals and self-efficacy primarily focused on formal educational experiences, potentially missing informal or extracurricular factors that shape students' capacity to address infrastructure and technology disparities.

Additionally, the study's timeframe (2021-2023) coincided with unique global circumstances that may have influenced students' experiences and perspectives. The COVID-19 pandemic fundamentally altered international fieldwork opportunities, with many programs forced to suspend international travel and shift to remote collaboration with partner communities. The pandemic also accelerated existing conversations about the sustainability of projects led by expats and the potential for locally led projects, given their necessity to function during COVID-19 travel restrictions. The study period also followed the 2020 Black Lives Matter protests and subsequent racial justice movements, which catalyzed unprecedented attention to decolonization and anti-racism within humanitarian engineering and gave momentum to aid localization efforts, influencing how students viewed their future roles in the field. Furthermore, as humanitarian engineering programs are relatively new and still evolving, the findings may reflect a particular moment in HE education's development rather than established patterns.

The researchers' positionality - as women from the United States with higher education degrees - may have shaped the interpretation of participants' narratives despite conscious efforts to maintain objectivity. Furthermore, while the longitudinal interview approach provided rich data, it relied on self-reported experiences and perceptions, which may not fully capture all aspects of students' educational development.

These limitations suggest several promising directions for future research. Longitudinal studies following students from program graduation through early career years would better illuminate the connection between educational experiences and professional outcomes. Comparative studies examining humanitarian engineering programs with different pedagogical approaches and program structures could identify effective practices for developing social justice capabilities, while investigation of informal and extracurricular factors could provide insights into students' development of critical consciousness and resistance behaviors. Additionally, expanded research on the experiences of underrepresented groups in humanitarian engineering education, particularly students of color without LMIC ties, is needed, as well as evaluation of specific institutional support strategies that consider students' intersectional experiences across diverse backgrounds.

Future research should also examine how transformation efforts continue to shape HE education as initial momentum from racial justice movements potentially wanes, and as programs become more established and potentially standardized across institutions. Such research would help address current limitations while advancing the understanding of preparing diverse cohorts of humanitarian engineering students for impactful careers addressing global infrastructure and public service disparities.

Table 6-2 Dissemination

Submitted Journal Articles:
Stine, E., Javernick-Will, A., and Tanksley, T. “Exploring Concerns in Equity-Focused Career Goals Among Humanitarian Engineering Students: Investigating the Influence of Graduate Education.” Submitted to: *ASCE Journal of Civil Engineering Education.* Accepted: April 2025 Stine, E., Tanksley, T., and Javernick-Will, A. “Nurturing Transformational Resistance: How Humanitarian Engineering Education Shapes Students' Capacity to Challenge Systemic Inequality.” Submitted to: *Journal of Engineering Education*. Submitted: August 2024, Revisions Pending Stine, E., Tanksley, T., and Javernick-Will, A. “The Unseen Labor of Being Included: Community Cultural Wealth and Supporting Students With Familial Ties to Low and Middle-Income Countries in Humanitarian Engineering” Submitted to: *Journal of Women and Minorities in Science and Engineering*. Submitted: October 2023 Stine, E., Javernick-Will, A., and Tanksley, T. “Developing Social Justice Self-Efficacy in Humanitarian Engineering Graduate Education”. Planned submission to: *ASCE Journal of Civil Engineering Education*. Submitted: April 2025
Journal Articles On Related Topics Outside of Dissertation
Pandey, M., Stine, E., and Javernick-Will, A. and Tanksley, T. “Examining Aid Localization in Humanitarian Engineering: Causes, Perspectives and Practices”. Submitted to: *Development in Practice.* Submitted: May 2024. Revisions Pending Burleson, G., J. Lajoie, C. Mabey, P. Sours, J. Ventrella, E. Peiffer, E. Stine, M. Stettler Kleine, L. MacDonald, J. Austin-Breneman, A. Javernick-Will, A. Winter, J. Lucena, D. Knight, S. Daniel, E. Thomas, C. Mattson, and I. Aranda. 2023. “Advancing Sustainable Development: Emerging Factors and Futures for the Engineering Field.” Sustainability, 15 (10): 7869. Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/su15107869.
Conference Proceedings Published
Stine, E., A. Javernick-Will, and T. Tanksley. 2024. “Navigating Transformational Resistance: Exploring Humanitarian Engineering Students' Capacities for Addressing Systemic Causes of Infrastructure Service Disparities.” *2024 ASEE Annu. Conf. Expo.* Portland, USA

Stine, E., A. Javernick-Will, and T. Tanksley. 2024. “The Evolving Career Aspirations of Socially Minded Engineering and Construction Students.” *Am. Soc. Civ. Eng. 2024 Constr. Res. Congr.* Des Moines, USA.

Stine, E., A. Javernick-Will, and T. Tanksley. 2023. “Conformist Motivation Towards Social Justice in White Humanitarian Engineering Graduate Students.” *2023 Eng. Proj. Organ. Conf.* Berlin, Germany

Presentations with Abstracts

Stine, E., A. Javernick-Will, T. Tanksley, and M. Pandey. 2023c. “Social Justice Self-Efficacy Growth in Humanitarian Engineering Students: Longitudinally Tracking the Learning Environments Conducive to Students’ Success at Activism in Graduate School.” 26th Annual Colloquium on International Engineering Education (ACIEE).

Pandey, M., A. Javernick-Will, E. Stine, and T. Tanksley. 2023. “Comparing the Career Goals of Humanitarian Engineering Students with the Career Realities of Humanitarian Engineering Practitioners.” 26th Annual Colloquium on International Engineering Education (ACIEE).

Stine, E., A. Javernick-Will, and T. Tanksley. 2023. “Understandings of White Saviorism in Future Development Practitioners.” Colorado WASH Symposium.

(Invited Speaker) Stine, E. 2022. the STI Forum: Preparing the Future Engineering Workforce to Achieve the SDGs Through Multi-Stakeholder Engagement

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Appendix A: Interview Guides

Fall 2021 Interview Guide with Probes:

What aspects of a career are important to you? (types of tasks, freedoms, items, work environment, topic)

Could you please describe your career goals? Please tell me a story of what led you to your current career goals

- What experiences have led you to these career goals?
- Have any experiences made you question these career goals?
- Have any experiences made you grow more confident in these career goals?
- What aspects of your identity do you think have affected these experiences or career goals?

How do you believe an HE education can help you achieve your career goals?

In what ways do you feel confident or not confident you can achieve these career goals?

- How do you believe your HE program will help you achieve your dream career?

Depending on what the student is discussing, we may ask a variety of the remaining questions:

What barriers to an HE education and career have you faced or observed others facing?

- What structural inequalities or biases have you observed or do you perceive in development work or education

Could you describe a time when an organization, peer, or authority figure was performing or discussing development in a way you disagreed with?

- Did you resist their actions in any way? What would need to happen for you to be comfortable resisting?
- In what ways do you feel confident or unconfident in performing decolonial/ anti-racist/social justice practices

What dominant narratives do you see in the HE field - such as “who should be a HE student” or “how HE work should take place”

- How would you define (de)colonialism and/or anti-racism (Social Justice) at this particular moment in the program? How do these theories and practices look in your future career?
- What experiences have made you reflect on or learn about racism, colonialism, or social justice?

Winter 2022 Interview Guide with Probes:

Overall, how did you feel about your last semester? - Was it what you expected?

(Personal SJ experiences/reflections) How have you learned about topics such as racism, colonialism, power dynamics, or ethics in your classes or research over the past semester?

- Did any of these experiences align with or challenge your own worldviews?
- What areas are you trying to educate yourself on?-and what class is that in?

(Interpersonal SJ experiences/reflections) Have you had any interesting conversations on these topics that you can share?

- Could you tell me how this conversation occurred? Were there any people, experiences, biases, contexts that made this particularly interesting?
- Were there any times you heard someone (a friend, peer or professor) talking about development in a way you thought was problematic? Could you describe that experience for me?

(Community SJ experiences/reflections) did you do or are preparing to do any HE-related work with a specific community over the past semester? This could be research, work, a class project, an experiential, a club, or community service.

- If so, can you tell me about it?
- How are you trying to make this work successful?

Specifically, ethical, anti-racist, decolonized, have good power dynamics, have community context?

(Institutional SJ experiences/reflections) Many of us are learning about large institutions in HE, both in classes and research, as well as about actors in development (ngo, governments).Are there ways that you feel these institutions need to change?

- What actors need to change?
- What HE educational programs need to change?
- What are you expectations that HE institutions can make progress towards equality?
- Please describe your self efficacy that you can make progress towards equality?
- Are there anyways you feel an HE practitioner/academic would have or not have the power to change these institutions?

Have your career goals changed at all over the last semester?

- What aspects of a career are important to you?

A large aspect of decolonizing development or ethical HE is figuring out what roles are appropriate for different people given their background and education.

- When thinking about a future career how do you think you could balance your career goals and what aspects of a career would be appropriate for you? This could include tasks, titles, power, location, compensation, or daily tasks
- In other words, how would you design your dream career so that it is both what you hope to do and what is appropriate?

Spring 2022 Interview Guide with Probes:

Overall, how did you feel about your last semester?

- Are there experiences that you would like to share?
- Are there any frustrating or exciting experiences you would like to share?

Career deep dive

How have career goals been influenced over the last semester?

- In what ways do you consider your dream job a humanitarian engineering job?
- Could you tell me as of now, what are aspects of a career you are really for? (types of tasks, freedoms, items, environment, topic)

- This is what you said last fall_____. What do you think of that? Can you think of anything over the past year (or semester) that has shifted your current priorities?
- What is a HE job or company that you may be someday interested in?
- What is the daily work life of an HE practitioner/academic as opposed to someone in a more traditional engineering career
- What about this attracts/repels you to each of these career options?

(Personal SJ experiences/reflections) How have you learned about topics such as racism, colonialism, power dynamics, or ethics in your classes or research over the past semester?

- Did any of these experiences align with or challenge your own worldviews?
- What areas are you trying to educate yourself on?-and what class is that in?

When is a time when you found parts of your home culture or life to help you in navigating your way in graduate school?" or,

- Do you feel you can bring your personal knowledge, experiences, and expertise to your graduate program? If so,

(Interpersonal SJ experiences/reflections) Have you had any interesting conversations on these topics that you can share?

- Could you tell me how this conversation occurred? Were there any people, experiences, biases, contexts that made this particularly interesting?
- Were there any times you heard someone (a friend, peer or professor) talking about development in a way you thought was problematic? Could you describe that experience for me?

(Community SJ experiences/reflections) did you do or are preparing to do any HE-related work with a specific community over the past semester? This could be research, work, a class project, an experiential, a club, or community service.

- If so, can you tell me about it?
- How are you trying to make this work successful?

Specifically, ethical, anti-racist, decolonized, have good power dynamics, have community context?

(Institutional SJ experiences/reflections) Many of us are learning about large institutions in HE, both in classes and research, as well as about actors in development (ngo, governments).Are there ways that you feel these institutions need to change?

- Please describe your self efficacy that you can make progress towards equality?
- What are you expectations that HE institutions can make progress towards equality?
- Are there anyways you feel an HE practitioner/academic would have or not have the power to change these institutions?

Fall 2022 Interview Guide with Probes:

Overall, how is school/work going? - are there experiences that you would like to share?

(probe) Are there any frustrating or exciting experiences you would like to share

The next questions really depend on where a student is in their education and if they had a summer internship/practicum/research experience.

Summer Questions

How did your summer go? (If they had an internship or Practicum)

- What were the most influential experiences?
- Have you been reflecting on any career goals?
    - Did your career goals change? If so, how (in what ways)? And Why?
- Did your expectations of what a humanitarian engineering job entails change?
    - Probe: This could be in terms of tasks/activities or impact
- What aspects of your summer would you like to, or not like to replicate in your future career?
- Did you meet any others doing Humanitarian work? Are there aspects of their life/actions/job that you want to replicate or not replicate?

- How do you think your work/project was or wasn't aligned with social justice and decolonization?
    - How did what you were hoping to accomplish change throughout the summer?
    - Do you think the project/company or your level of accomplishments could have been improved?
    - How did your summer influence your desire to have a positive impact on the world in your life?
    - (if there is a change) What influenced this new change in your desires?
    - How are you feeling with respect to the difficulty or systematic barriers to having a long-lasting impact?
    - What power could you see you or another engineer having to change any form of systematic oppression?
- How did your race end up impacting your experience?
    - How did race impact your interactions with others?
    - How did your race impact your perspective on the summer?
    - How did race impact your success or project?

Job Search

Are you currently job searching? If so, how is that going?

- What is your job search process?
- What types of jobs are you looking for? Is there any job task, company, or aspect of a job you are particularly interested in or uninterested in?
- What impacts do you hope to make? (What inspires you or repels you from different jobs?)
- What is your process of deciding whether or not a future job aligns with your values or understanding of Social Justice?
- What is your confidence in finding the job you want?
- How do you feel your HE education has or hasn't helped you in getting a job?

- What might your larger career pathway look like?
- Are the careers you are looking into the ones you hope to be in for a long time or are you hoping to move around?

If they found a job

Tell me about the Job you got

- What are you hopeful or nervous about
- What aspects do you expect? in terms of daily tasks, work environment, bosses, topics, compensation location? How does this align and misalign with what you want in a job?
- What impact do you hope to have in this job?
- How does the job align or misalign with the job you were expecting to get when you first entered the program?

(Personal SJ experiences/reflections) How have you learned about topics such as racism, colonialism, power dynamics, or ethics in your classes or research over the past semester?

- Did any of these experiences align with or challenge your own worldviews?
- What areas are you trying to educate yourself on?-and what class is that in?

When is a time when you found parts of your home culture or life to help you in navigating your way in graduate school?" or,

- Do you feel you can bring your personal knowledge, experiences, and expertise to your graduate program? If so,

(Interpersonal SJ experiences/reflections) Have you had any interesting conversations on these topics that you can share?

- Could you tell me how this conversation occurred? Were there any people, experiences, biases, contexts that made this particularly interesting?
- Were there any times you heard someone (a friend, peer or professor) talking about development in a way you thought was problematic? Could you describe that experience for me?

(Community SJ experiences/reflections) did you do or are preparing to do any HE-related work with a specific community over the past semester? This could be research, work, a class project, an experiential, a club, or community service.

- If so, can you tell me about it?
- How are you trying to make this work successful?

Specifically, ethical, anti-racist, decolonized, have good power dynamics, have community context?

(Institutional SJ experiences/reflections) Many of us are learning about large institutions in HE, both in classes and research, as well as about actors in development (ngo, governments).Are there ways that you feel these institutions need to change?

- What HE educational programs need to change?
- What are you expectations that HE institutions can make progress towards equality?
- Are there anyways you feel an HE practitioner/academic would have or not have the power to change these institutions?
- Please describe your self efficacy that you can make progress towards equality?

Is there anything else you are hoping to talk about or would want me to ask all students in my final interview?

Appendix B: Coding Dictionary for Chapter 4

Category	Definition
Increased Personal	A student engages in critical self-reflection where they challenge their own biases and deepen their understanding of factors related to unequal access to essential services (water, sanitation, energy, food, healthcare, transportation, shelter). This manifests through: • Challenging their own biases and assumptions • Deepening understanding of systemic inequities • Recognizing privilege and power dynamics • Developing more complex understanding of social justice issues • Reflecting critically on past actions and perspectives
Decreased Personal	A student feels stuck and struggles to engage in critical self-reflection about their own biases and understanding of factors related to unequal access to essential services. This manifests through: • Expressing confusion about their role or impact • Having difficulty processing new perspectives • Feeling overwhelmed by complexity • Being unable to integrate new understanding with existing views • Avoiding or resisting deeper examination of assumptions
Increased Interpersonal	A student feels improved confidence to challenge others' biases, deepen others' understanding, and motivate others to address factors contributing to unequal access to essential services. This manifests through: • Successfully engaging others in difficult discussions • Teaching or sharing critical perspectives effectively • Developing strategies to change others' views • Building confidence in cross-cultural communication
Decreased Interpersonal	A student becomes stuck and struggles in their confidence to challenge others' biases, deepen others' understanding, and motivate others to address inequity. This manifests through: • Expressing doubt about ability to convince others • Feeling discouraged about failed attempts to change perspectives • Becoming intimidated about challenging others • Avoiding difficult conversations about bias • Struggling with cross-cultural communication.

Increased Community	A student feels improved capacity to directly enhance access to essential services in marginalized communities through implementation of technical solutions, program design, or other direct interventions. This manifests through: • Successfully implementing community solutions • Discovering effective ways to contribute • Developing sustainable approaches for impact • Creating meaningful partnerships with communities • Designing culturally appropriate interventions
Decreased Community	A student becomes stuck and struggles in their capacity to improve access to essential services in marginalized communities. This manifests through: • Questioning effectiveness of humanitarian engineering approaches • Encountering seemingly insurmountable barriers • Losing confidence in ability to contribute meaningfully • Struggling to find appropriate role within projects • Doubting sustainability of interventions
Increased Institutional	A student feels improved confidence in their ability to influence policy, culture, or norms within engineering-related institutions to address unequal distribution of essential services. This manifests through: • Identifying viable pathways for systemic change • Developing strategies to influence institutions • Growing confidence in ability to shift culture/policy • Building coalitions for organizational change • Creating innovative approaches to reform
Decreased Institutional	A student becomes stuck and struggles in their confidence to influence policy, culture, or norms within engineering-related institutions addressing inequity. This manifests through: • Feeling powerless to change systemic issues • Doubting ability to create structural change • Becoming overwhelmed by organizational inertia • Losing hope in possibility of reform