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Redefining High School Engineering Education: Integrating Environmental Justice for Transformative Learning Experiences

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Dr. Ivonne Santiago is an Associate Professor of Civil Engineering at the University of Texas at El Paso (UTEP) and the Co-Director of the NSF Engineering Research Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE). She is deeply committed to advancing equity, particularly in providing access to safe drinking water and promoting clean transportation solutions as catalysts for social mobility. Through her work, she actively advocates for these causes and engages her students in hands-on learning experiences at local, regional, and international levels. Dr. Santiago's expertise spans four key areas: 1. Equity and Environmental Impacts of Clean Transportation and Electrified Infrastructure: Dr. Santiago ensures that the voices of community partners are heard and incorporated in decisions regarding the placement of electrified infrastructure. Her work includes modeling greenhouse gas emissions on regional and national scales, supported by funding from NSF through ASPIRE and the Federal Highway Administration through the City of El Paso. 2. Water Treatment, Resource Recovery, and Conservation: She leads pilot-scale projects on water reuse, resource recovery, and brine reduction from desalination, utilizing advanced technologies such as membrane processes and electrodialysis. These efforts are funded by El Paso Water, the U.S. Bureau of Reclamation, the National Alliance for Water Innovation, and NOAA. 3. Engineering Workforce Development: Dr. Santiago champions the success of Hispanic students and Latinas in STEM and academia. She provides opportunities for UTEP students to engage in study-abroad programs in Colombia, Brazil, and Haiti. These initiatives are supported by NSF, the Department of Energy, and the Department of Education. 4. Community Outreach to Underserved and Indigenous Communities: Her outreach efforts focus on providing safe drinking water to communities along the U.S.-Mexico border and in Colombia. These projects are funded by the U.S. Department of State, NIH, and the World Business Council for Sustainable Development. Beyond her academic and research roles, Dr. Santiago has served as Chair of the Public Service Board, overseeing El Paso Water and contributing to the management of critical water resources. Dr. Santiago's impactful contributions have earned her numerous prestigious awards, highlighting her dedication to her profession, students, and community. Among her notable accolades are the 2025 Best Practice Award for the World Expo under the theme "Designing Future Society for Our Lives," for her collaboration with Colombian partners on the "Uni Masaquerí Alliance: Clean Water Supply for the Future of Communities;" the 2023 El Paso Women of Impact Award, the 2023 McDonald's Hispanos Triunfadores in STEM Award, the 2014 University of Texas System Regents' Outstanding Teaching Award, the 2018 ASCE Texas Section "Service to the People" Award, and the 2019 Engineer of the Year Award from the Texas Society of Professional Engineers in El Paso. These honors underscore her unwavering commitment to sustainable development, equity, and excellence in engineering.

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Abstract

This practice paper supports the notion of a critical need for engineering education to embed social and environmental justice (EJ) issues and concepts into curricula. In doing so, we provide critical skills and empathy development for the future engineering workforce to address real-word challenges with equity and justice. In recent years, there has been considerable improvement in providing students in higher education with professional skills needed to be employable and successful in their respective profession. Such skills include communication, ethics, collaboration, leadership, and global awareness (including the social and environmental impacts of engineering). Yet, much of the engineering education employed in the K-12 setting focuses on the technical outcomes and skills. This study explores the use of an environmental justice-focused curriculum, namely StoryMaps that facilitate a deeper exploration of the complex interconnections of air quality, transportation, and engineering, as a part of a larger *Creative Engineering Design* course. Specifically, we examine a cohort of students across different school campuses who interacted with StoryMaps that highlight the disparities in air quality and their correlation with transportation systems. Through qualitative and quantitative analyses, we assess changes in students' understanding of environmental justice concepts and their ability to enact these principles in real-world contexts. Our findings reveal that these EJ-themed StoryMaps not only promote critical thinking and awareness but also empower students to recognize their role in addressing environmental inequities. This research contributes to the ongoing dialogue about innovative teaching strategies in engineering education and underscores the importance of integrating social justice themes into technical curricula.

1. Introduction

The purpose of this practice research paper is to underscore the profound need for social and environmental justice (EJ) teachings in engineering education, especially at the K-12 level. In this study, we evaluate how high school students' understanding and perceptions of environmental justice shift in response to completing lessons on EJ framed through interactive StoryMaps. Through these StoryMaps, students were able to engage with real-world multimedia tools to understand EJ through the lens of air quality and transportation and evaluate the implications for their communities and others beyond. This paper builds on prior research identifying environmental justice education as a critical and valuable means to address sustainability and social equity while empowering citizens to commit to actionable solutions.

1.1 Motivation for This Study

This work was initiated by the authors' interest in reimagining engineering education where students are prepared with intuitive components of ethics, change agency, systems-of-systems thinking, epistatic humility, life-long learning, effective communication, and informed decision making. We posit that engineering education should foster a critical understanding of the broader societal implications of engineering decisions, equipping students to consider ethical, social, and environmental consequences in their practice as future engineers. This curriculum and study seek to contribute to the growing body of scholarship on transformative engineering education by offering empirically grounded insights into how students engage with issues of EJ, sustainability, and societal impact in engineering contexts.

1.2 Background

It is well-established that communities of color experience higher levels of exposure to and harm from environmental hazards and undue environmental justice challenges. In fact, in our current state within the U.S., an individual's zip code remains one of the strongest indicators of their health and overall well-being [1]. Since the rise of the EJ movement in the 1960's, the Environmental Protection Agency's creation of Office of Environmental Equity (later renamed Office of Environmental Justice) in the 1990's, and soon after the establishment of Executive Order 12898 in 1994, which directs federal actions to address environmental justice in minority populations and low-income populations [2], the intent to confront environmental justice issues has increased, yet despite these efforts and intentions, low-income communities, particularly those of color, still disproportionately endure the negative impacts of environmental problems [3], [4], [5]. The Covid 19 pandemic intensified existing environmental justice challenges, but it also created a pivotal moment for action and awareness.

The Pandemic exposed pre-existing inequities but also created a new consciousness among adolescents whose normalcy was abruptly confronted with increased awareness and engagement related to racial injustices [6][7] and environmental inequities [7]. Students may not initially recognize their lived experiences as environmental inequity as they often do not have the language, awareness, or framework to identify these experiences as environmental injustices. However, the Pandemic brought much of this truth and recognition to light for students across the United States. Compounding this with other issues, like the digital divide and limited access to healthcare resources, students in the post-pandemic era are traversing their lives and education with little to no knowledge on the concept of environmental justice.

Providing students with education related to environmental justice not only allows them to become empathetic citizens but provides a roadmap for them to navigate their own lived experiences and how they can take actionable steps towards injustices as adults. Schools and teachers play a vital role helping students in their quest for global understanding [8]. As a result, these students can be inspired to cultivate a strong sense of ethical responsibility to address and rectify the injustices that impact communities across the globe [8][9].

More recently, undergraduate programs have begun aligning research and educational aims with environmental justice principles [10],[11],[12]. Such programs foster critical thinking, ethical responsibility, empathy, and leadership skills among students. By cultivating empathy through direct engagement with EJ issues, these programs increase the likelihood of sustained, actionable efforts toward equity and sustainability throughout adulthood. Additionally, they promote community-centered solutions through collaborative research [12], advancing local environmental conditions and public health outcomes. By aligning undergraduate educational goals with EJ principles, such programs contribute to inclusive education, social equity, and long-term societal change. However, such programs and content are often not included or available in the K-12 space.

Engineering education is becoming more widely implemented and standards-aligned in K-12 education, particularly at the high school level (grades 9-12). Technical skills applied and learned in engineering education prepare students to take on the technical aspects of society's

complex problems, but non-technical (professional) skills equip students with a moral responsibility to tackle such problems through a humanistic approach. Yet, most curricula focus almost entirely on the technical skills related to the field of engineering without addressing the social and ethical dimensions of environmental issues, including environmental justice. This is a result of a number of factors including, simply lacking comprehensive curricula that incorporate EJ principles that aligns with state/school standards, educators who feel unprepared to teach EJ topics due to a lack of training and resources, schools lacking the necessary materials and technology to effectively teach concepts revolving around EJ, and the lack of political will to include environmental justice in the school lessons due to concerns about teaching topics perceived as politically or socially polarizing.

This gap in environmental justice education within engineering education has significant implications for the future engineering workforce. As society grapples with increasingly complex issues - such as climate resilience, equitable infrastructure, and sustainable energy systems - engineers will need not only advanced technical skills but also a strong foundation in empathy [13][14], critical thinking, ethical decision-making, and collaboration. These professional skills are essential for creating innovative solutions that address both technical challenges and the needs of diverse communities. By integrating EJ education into K-12 engineering education, we can cultivate a generation of engineers who are not only technically proficient but also morally driven to design equitable and sustainable solutions for real-world problems. This balanced approach will better prepare students to succeed in a workforce that increasingly values socially responsible innovation [11].

Bridging the gap between technical expertise and social responsibility in engineering education requires innovative, pedagogical approaches that engage students in real-world problem-solving. One such approach involves the use of StoryMaps—digital, narrative-driven tools that integrate multimedia, maps, and data with storytelling to convey complex issues in an interactive and visually engaging format [15]. StoryMaps offer a unique way to teach environmental justice by presenting interconnected topics—such as transportation inequities and environmental health impacts—through a lens that fosters critical thinking, empathy, and systems-level understanding. By combining real-world problems, like environmental inequities, with geographic visualizations, this pedagogical method enhances students' ability to analyze multifaceted challenges, empowering them to consider equitable solutions in engineering contexts.

2. StoryMap Design and Implementation

2.1 StoryMap Design

From efforts addressing the research team's workforce priorities, the *Creative Engineering Design (CED)* [16] course was developed and piloted over three years (2021-2024) among 12 partnering teachers at 16 schools in Colorado, Indiana, Texas, and Utah, and over 1200 diverse students. *Creative Engineering Design* is an introductory-level, project-based learning high school course that explores engineering concepts and real-world engineering applications through the lens of sustainable electric vehicle (EV) technology.

Integrated within the course is a series of five Environmental Justice (EJ) StoryMaps [17] exploring the connections between air quality, transportation, and engineering. The EJ StoryMap Collection was created using the ArcGIS platform, which is a web-based storytelling tool that

integrates succinct text and academic vocabulary, images, infographics, video, and interactive geospatial maps that support the learning and application of STEM and engineering-related content from an environmental justice perspective. The collection provides background knowledge from reliable sources like The Environmental Protection Agency (EPA) AirNow program, the EPA EJScreen Tool, The NOAA National Weather Service, and U.S. Census Data, among others, to build students' understanding of concepts presented in a visual and interactive format. The EJ StoryMap engineering curriculum aligns to Next Generation Science Standards (NGSS) and encourages critical thinking, highlights real-world applications, and fosters awareness of social inequities at the local, regional, and global level (Table 1).

The framework for each EJ StoryMap includes the following sections:

- Essential Question (title)
- Introduction – Think About It
- Content Knowledge Building
- Geospatial Data Explorations
- Engineering Connection
- Discussion – Talk About It

Table 1. EJ StoryMap Collection

StoryMap	**Essential Question**	**Objective and Overarching Task**
StoryMap #1	What is air quality and why does it matter?	Students learn about particulate matter (PM) pollution, the sources of PM, and how PM air pollution is measured using AirNow.gov Air Quality Aware and the EPA's EJScreen geospatial maps to explore local air quality and transportation concepts.
StoryMap #2	How does poor air quality affect our health?	Students dive into how air pollution affects public health, who is at risk, and actions to take on air quality advisory days.
StoryMap #3	Are air quality and transportation impacts equitable?	Students learn about environmental justice and its origins, community-based environmental justice, and the role of our transportation system in environmental justice.
StoryMap #4	How does transportation affect the environment?	Students learn about cars and carbon emissions through the impacts of traditional gas-burning vehicles and newer technology of electric vehicles on the environment, the relationship between greenhouse gases and transportation, and analyzing transportation options and solutions.
StoryMap #5	How do electric vehicle batteries impact our world?	Students build on the understanding of battery basics and lithium-ion batteries that power electric vehicles (EVs) and learn environmental impacts of lithium used to power electronics, and explore solutions to advance a more sustainable battery-powered future.

2.2 StoryMaps Implementation

The StoryMaps, which typically take one to three 45-minute class periods to teach, are embedded into the *CED* curriculum and are independent of the other modules within the *CED* course. Because of this, piloting teachers used their discretion on when to employ the StoryMaps, e.g., at

the beginning, middle or towards the end of the course. Evaluation feedback from piloting teachers not related to this research study suggests that using the StoryMaps as an introduction to the course may help better frame the perspective of *Creative Engineering Design*, so that students have and retain the EJ learnings throughout the duration of the course. The StoryMaps were not broken up, however, and were covered as an entire 'unit' when taught to the students. The duration dedicated to each StoryMap was determined at the discretion of the teachers, but the participating teachers typically spent two to three days on each StoryMap.

3. Methodology

3.1 Participant Recruitment

Partnerships with local high schools were established as part of the ASPIRE ERC Pre-College Curriculum and Engagement initiatives. Partnered schools dedicated a teacher to pilot the *Creative Engineering Design* (CED) course, provide constructive feedback on lessons and StoryMaps, and participate in weekly update and professional development meetings. Students enrolled in the CED course were provided with the opportunity to participate in an Institutional Review Board (IRB)-approved study throughout the duration of the CED course. Participation was voluntary and did not have an impact on students' course performance or grade. This study included students from two single-gendered (all-boys/all-girls) private high schools in a predominantly Hispanic, U.S./Mexico Border City in the U.S. Variations in gender responses were not analyzed in the study. A separate publication will explore distinctions in gender-based engineering identity and perceptions along with EJ understandings. There was a total of 34 responses to the pre-survey, which was administered at the beginning of the course, and 26 responses to the post-survey, which was administered at the end of the course.

It is important to note that the city in which this study was conducted faces notable air quality challenges, particularly concerning ozone pollution. According to the American Lung Association's 2024 "State of the Air" report [18], the city ranks 14th worst in the nation for ozone pollution, earning an "F" grade in this category that year and every year since 2000 when the organization released its first report. The city performs moderately well in terms of particle pollution, typically seeing Air Quality Index (AQI) of 25 to 120 ('good' to 'moderate'), however, the summer months tend to be higher and the city experiences levels of 'unhealthy' air quality (AQI > 130) during this time of the year.

3.2 Measures

Students who participated in the IRB-approved study, with parental consent, were assessed using pre- and post-surveys to evaluate changes in their understanding and enactments of environmental justice concepts. The evaluation instrument consisted of two components. The first component measured students' engineering identity and was adapted from Godwin [19]. This section focused on three aspects: students' interest in engineering, their perceived recognition by others as engineers, and their self-assessed performance and competence in engineering. As the primary focus of this study was environmental justice, data from this section were excluded from the analysis.

The second component of the instrument examined students' understanding, self-perceptions, and enactments of environmental justice. Students were prompted to provide a definition of environmental justice based on their current understanding—this was the only open-ended

question in the survey. All remaining items were evaluated using a 5-point Likert scale, with response options ranging from “strongly disagree” to “strongly agree.” The environmental justice section included eight items assessing environmental beliefs, seven items evaluating environmental self-perception, and five items measuring environmental priorities and enactments.

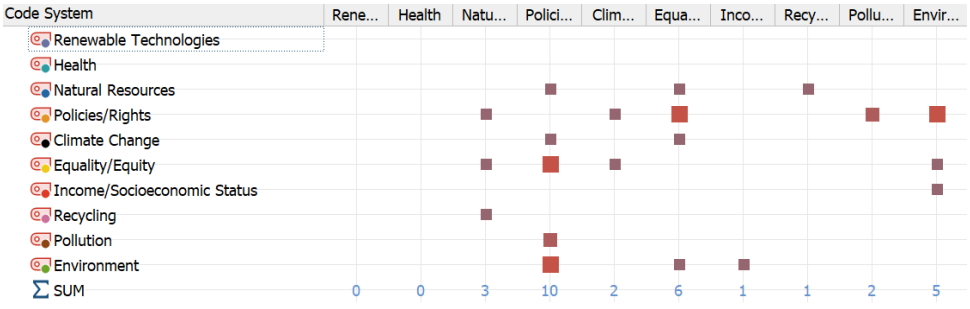
3.3 Analysis

Thematic analysis of student responses to the open-ended environmental justice definition question was conducted using MAXQDA qualitative data analytical software [20]. Using a grounded theory approach, recurring themes among student responses were systematically identified and coded using MAXQDA’s inVivo coding. The coded segments were subsequently analyzed and compared using the Code Relations Browser. For the Likert-scale survey items, responses were converted to ordinal data, and presuming non-parametric nature of Likert data, a Wilcoxon Signed-Rank Test was conducted to compare differences between pre- and post-feedback scores.

4. Findings and Implications

4.1 Students’ Understanding of Environmental Justice

The concept of Environmental Justice is very rarely taught outside of higher education; therefore, this study did not entail any sort of rubric or criteria for evaluating students’ responses to the open-ended question for defining EJ. We were interested in learning what themes and language students would use in their responses. The MAXQDA coding features allowed us to extract key terms and ideas and compare such terms as reflected in the pre- and post-survey responses. From those student responses, MAXQDA identified 10 thematic constructs (*Renewable Technologies, Health, Natural Resources, Policies/Rights, Climate Change, Equality/Equity, Income/Socioeconomic Status, Recycling, Pollution, and Environment*) which were used as the coding system to evaluate differences in the pre-/post-responses.



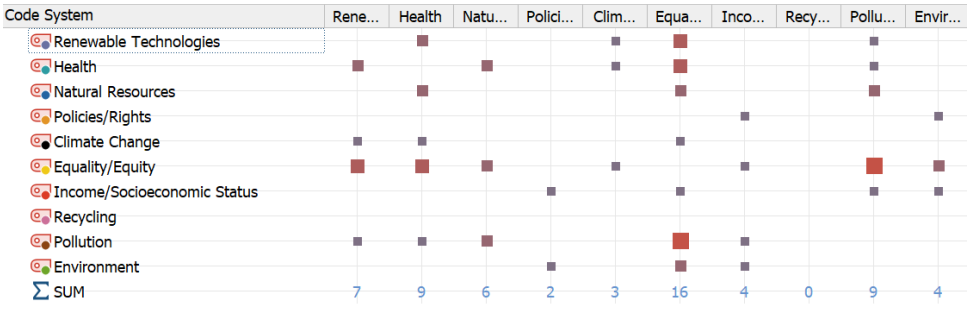


Figure 1. Code Relations Browser visualization of (top) Pre- and (bottom) Post-Survey open-ended EJ definition responses illustrating frequencies for each of the coded themes extracted from student responses (MAXQDA 2020).

Figure 1 illustrates how students' definitions changed as a result of participating in class lessons incorporating EJ-themed StoryMaps. Prior to these lessons, many of the student responses heavily focused on the idea/definition that EJ is or revolves around policies and rights of people to have a clean environment, with occasional mentions of environmental issues such as pollution, recycling, and natural resources. Additionally, references to the "environment" in these responses consistently framed it in relation to nature and the outdoors, rather than as an integral aspect of everyday life (Table 2). Pre-survey definitions also revealed a notable number of students who associated EJ with principles of equality and fairness.

After learning about environmental justice and utilizing multimedia resources and tools like Air Quality Aware and EJ Screen to explore air quality and social/environmental vulnerabilities in their own communities along with others across the nation, students' understanding of EJ were deepened in several ways. Post-survey definitions revealed that students gained a more nuanced awareness of how environmental issues intersect with social and economic inequalities, moving beyond a simplistic view of EJ as policy-focused to a broader understanding of real-world impacts on marginalized communities (Figure 1). Additionally, the StoryMaps, which highlighted the disparities in air quality and their correlation with transportation systems allowed students to recognize that health is a central component of EJ, as environmental inequities often manifest in disproportionate health outcomes, particularly in communities facing higher exposure to pollutants and limited access to healthcare. The notion of health being related to EJ was not even mentioned in any pre-survey responses. Furthermore, the StoryMaps' lens of transportation in the U.S. and the future of transportation, specifically electric vehicles, allowed students to see the role of emerging and renewable technologies not only as technical solutions but also as tools for promoting environmental equity by improving access to clean energy and technologies and reducing pollution in under-resourced communities (Table 2).

Table 2. Student response samples to open-ended EJ definition question

Highlighted Theme	**Pre or Post Survey Response**	**Student Quote**
Environment	Pre-Survey Response	*Stopping people from destroying the environment in certain places.*
Environment	Post-Survey Response	*Knowing that some communities face more environmental problems than others and doing something to fix that.*
Equality/Equity	Pre-Survey Response	*It sounds like a mix of taking care of the environment and making sure people aren't treated unfairly because of it.*
Equality/Equity	Post-Survey Response	*Environmental justice is about fairness -*

		making sure that no one suffers more from pollution just because of their race or income.
Natural Resources	Pre-Survey Response	*Something to do with making sure we recycle and don't waste resources.*
Natural Resources	Post-Survey Response	*Environmental justice means designing transportation systems that don't pollute and harm people's health, especially in communities already struggling with bad air.*

This integrative learning approach of embedding EJ-focused StoryMaps into engineering education not only enriches engineering education in secondary (high school) education, but it is promising in building skills like critical thinking, critical environmental consciousness, global awareness, and potentially activist identity formation. This is especially true when empowering youth who live in areas of injustice [9] where such foundational knowledge during formative years can lay the foundation for building strong, resilient communities. Additionally, this learning approach can have a significant impact on the future engineering workforce as students turned engineers not only pledge the Engineer's Oath from a professional obligation, but take a personal commitment to community health, well-being, equity, and justice.

4.2 Students' Beliefs, Self-perceptions, and Environmental Priorities

Integrating the EJ-focused StoryMaps within the engineering curriculum had a notable impact on students' environmental beliefs and their recognition of personal responsibility in addressing EJ. Prior to the EJ lessons, student responses to some of the Likert items demonstrated the narrow lens that they saw the world and implications of issues like pollution within the U.S. However, these beliefs and ideas shifted after completing the lessons as many of the students became aware of the inherent societal inequities and how they feel they should be addressed (Table 3). Also, in some areas in pre-survey responses majority of students selected responses reflecting their agreeance to a statement, that support (number of responses) became stronger in post-survey feedback. For example, for the question of "*People making decisions should treat ALL people equally when solving environmental problems"*, pre-survey responses reflected that students most commonly selected that they 'agreed' with this statement, while in post-survey responses students mostly selected that they 'strongly agreed' with this statement. Wilcoxon sign rank test revealed that student agreeance to this statement was significantly higher after the EJ lessons (Md = 5.0, n = 26) compared to before (Md = 4.0, n = 34), z = -3.497, $p < 0.001$, with a large effect size [22], r = 0.5. This was the case for other survey questions outlined in Table 3.

Interestingly, one question on the survey showed a regression in students' environmental self-perception. For the question of "*I have a special connection to the land where I grew up*," a notable switch from 'agree' to 'disagree' was shown (Table 3). Because there was no follow-up on why students selected the response they did after the EJ lessons, our conclusions are assumptive. This shift may be attributed to students' evolving perception of the environment, which expanded in scope and context. As their understanding deepened, students became more aware of the limitations in their prior knowledge and developed a heightened sense of interconnectedness with environmental and social issues. Exposure to new information about

environmental justice, framed within the context of air quality and transportation, may have prompted students to reconsider their relationship with the communities in which they were raised, and as a result, realized the connection was not as deep as they once thought.

Exposure to EJ concepts reshapes key constructs in students' development - what they believe about the environment and the role of engineering, how they perceive themselves in relation to the environment and environmental issues, and how they act (or will act) on environmental problems. Shifts in beliefs transform their understanding of engineering from a purely problem-solving endeavor to a means of addressing systemic inequities and improving quality of life for marginalized communities. Helping students mature their environmental self-perception provides them with the opportunity to view themselves not just as learners or future engineers, but as active agents capable of contributing to equitable solutions. Furthermore, learning about environmental justice coupled with engineering education frames how students apply their knowledge and skills to real-world contexts; it encourages students to think holistically, considering not only the technical viability of their work but also the social and environmental consequences [11].

Table 3. Likert-scale survey responses for questions with the most significant change in response according to Wilcoxon Signed-Rank Test.

Survey Question	**Pre-Survey Response Mode (n = 34)**	**Post-Survey Response Mode (n = 26)**	**Statistical Significance and Effect**
Q3 Environmental pollution here in the US harms people all over the world.	Neutral (43% of respondents)	Strongly Agree (58% of respondents)	$p = 0.005$ $z = -2.828$ $r = 0.4$
Q4 Some people are treated unfairly when it comes to environmental issues and are more exposed to environmental hazards than others.	Neutral (53% of respondents)	Strongly Agree (58% of respondents)	$p < 0.001$ $z = -3.579$ $r = 0.5$
Q5 People making decisions should treat ALL people equally when solving environmental problems.	Agree (47% of respondents)	Strongly Agree (73% of respondents)	$p < 0.001$ $z = -3.497$ $r = 0.5$
Q9 I feel that everyone is responsible for helping the environment.	Agree (38% of respondents)	Strongly Agree (69% of respondents)	$p = 0.005$ $z = -2.805$ $r = 0.4$
Q15 I have a special connection to the land where I grew up.	Agree (38% of respondents)	Disagree (42% of respondents)	$p = 0.009$ $z = -2.630$ $r = 0.3$
Q19 People should reduce pollution and save energy by riding a bike, taking the bus, or sharing a ride.	Neutral (50% of respondents)	Strongly Agree (38% of respondents)	$p = 0.061$ $z = -1.874$ $r = 0.2$

4.3 *Limitations*

Despite the valuable insights provided by this study, certain limitations should be acknowledged to guide interpretation and future research. Though the *CED* course and pilots offered the opportunity to examine a large sample of students, due to logistical constraints and a modestly sized team, we were only able to gather IRB-approved feedback from the two private schools included in this study. It is important to note that the demographic makeup of these schools is slightly different from the average public school within the same city. Therefore, student experiences, and consequently responses, of those reflected in this study may differ from the average public-school student. Despite this, all students can benefit from environmental justice teachings. Another limitation was the lack of follow-up interviews to further investigate student responses. The one open-ended question provided a great deal of insight, and we acknowledge that more open-format dialogue with the students would allow us to examine in more detail the intricacies of student learning, understanding and changes in beliefs/perceptions/enactments. Lastly, the StoryMaps served as an easy, 'plug and play' means to teach about environmental justice. The StoryMaps also focused heavily on EJ in the context of transportation and air quality, which might not fit all engineering classes. The participating teachers felt comfortable facilitating the StoryMaps in their classes because of the ease of implementation, but this is not always the case for all teachers. Most educators struggle to effectively incorporate environmental justice topics into engineering education [21] for a number of reasons, but mainly because of their own lack of knowledge and understanding. In the face of climate change and the fact that many children endure the effects of climate variability and often environmental injustices, teachers would benefit from resources to help them support their children's environmental learning in a way that fosters emotional wellbeing and promotes hopefulness [23]. Because of this it is important to support educators with resources and information to help build their EJ literacy. Once the teachers have embodied the knowledge, they can then instill understanding and awareness within their own students [9].

5. Conclusion

The goal of this practice paper is to promote the integration of environmental justice in K-12 engineering education. We've demonstrated that when students engage with EJ topics—such as the intersection of transportation systems, air quality, and public health—their understanding and perceptions of EJ become more comprehensive, and this allows them to see engineering not merely as a technical field but as a discipline with profound social and ethical implications. Engineers of the future must be prepared to take on the challenges of complex problems in the light of climate change, political dysfunction and gridlock, and a changing society with ever growing needs. Engineering alone cannot solve grand societal problems, but a future engineering workforce equipped not only with advanced technical skills but also with professional skills such as critical thinking, empathy, collaboration, and a deep understanding of environmental justice can contribute to solutions that can create a more equitable and sustainable world.

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Disclaimer: The research and activities described in this article were conducted prior to the issuance of Executive Order 14151 on January 20, 2025. Since that time, certain educational

materials and resources referenced herein have been updated or revised to align with the requirements of the Executive Order.

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