Unsettling the Status Quo: Embedding Environmental Justice in Tech-Centered Environmental Education

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Abstract: This article explores the integration of Environmental Justice (EJ) frameworks into technology-focused environmental education, addressing systemic inequalities in technology development and environmental degradation. By embedding EJ principles into curricula, we propose a pedagogical framework that emphasizes active inclusion, participatory design, diverse epistemologies, and meaningful community engagement. The article critiques the dominant narratives in STEM and environmental education that neglect socio-political contexts, and emphasizes interdisciplinary approaches that connect social justice and technology. Drawing on case studies and recent research, the authors highlight strategies for creating equitable, justice-centered technological solutions while preparing students to tackle complex socio-technical challenges.

Keywords: environmental justice, education, pedagogy, technology.

Introduction

In recent years, the intersection of technology - whether through methods or applications - has gained increasing attention and use in the environmental education space and mainstream societal narratives. However, the dominant narratives within this space often overlook critical environmental justice issues, treating climate change and environmental degradation as an ahistorical, purely physical and technical phenomenon. For example, Stephens defines this as "Climate Isolationism," which refers to "the common framing of climate change as an isolated, discrete, scientific problem in need of technological solutions" (83). We seek to challenge and redefine the pedagogical and theoretical frameworks within tech-focused approaches to teaching environmental studies. By embedding environmental justice (EJ) principles and questions into technology's development and usage in environmental education programs, we can more thoroughly engage with systemic inequalities and historical contexts that shape environmental issues.

The modern environmental justice movement emerged in the early 1980's as Indigenous peoples, people of color, and low-income groups protested the inequitable placement of environmental harms in their communities (Mohai et al., 405). One result of this movement was the creation of the EJ field of studies, and in parallel development, the Principles of Environmental Justice at The Multinational People of Color Environmental Leadership Summit in 1991, which sought to

respect and celebrate all cultures, promote economic alternatives, and secure economic, political and cultural liberation for people and the environment. (People of Color Environmental Leadership Summit, 1991).

Since the birth of the movement, environmental justice has served as a critical framework that addresses the root causes of climate change and environmental destruction by focusing on systemic social oppression (Mohai et al., 405). This framework is essential for understanding and mitigating the impacts of environmental degradation, which disproportionately affect marginalized communities. Technological development—encompassing processes such as (materials and data) extraction, design, manufacturing, and disposal —often exacerbates these issues (these stages are described in environmental life cycle assessment [LCA] see: Kirchain et al., 693). For example, the petrochemical facilities in so-called "Cancer Alley," located in southern Louisiana, have caused severe health and environmental problems for local, predominantly Black communities, illustrating the disastrous consequences of environmental injustices engineered and perpetuated through such systems (Rosene, 502; Castellón, 15).

EJ also plays a critical role in the exponentially expanding computing industry in areas such as cloud computing, data center energy use, AI expansion, and electronic hardware. Recent empirical research has focused on biased AI algorithms and their risk to worsen climate change (Debnath et al., 1; Cowls et. al., 1) and environmental injustices (Rakova et. al., 2). In addition, problems revolve around the electronic hardware lifecycle: including conflict and environmental degradation from mineral mining on local communities across the Global South (Odell, 3; Rodríguez-Labajos, 245), gender and health issues with labor in manufacturing (Zhang, 359), and complex sustainability and human rights problems with electronic hardware disposal and recycling, often referred to as e-waste (Pellow, 490).

Despite the significant role that technology plays in perpetuating environmental injustices, there is evidence that Science, Technology, Engineering and Math (STEM)- focused environmental programs rarely incorporate an EJ framework. For example, in a study reviewing 297 Interdisciplinary, Environmental, and Sustainability (IES) programs, it was found that program leaders in STEM contexts were less likely to place importance on EJ content knowledge (Carlos Garibay et al., 933), which may result in less coverage of EJ in the actual curriculum. This study also found that IES programs overall have yet to fully integrate EJ content knowledge as a foundational component of the core curricula.

Another study reviewing proposed courses for a campus-wide sustainability requirement at the University of Vermont found that only 17% of the courses in STEM areas addressed EJ (Coleman & Gould, 229). In addition, a more recent investigation of two IES programs showed that Black, Indigenous, and People of Color (BIPOC) students reported a dearth of content that examined the intersection of environmental and social issues. These students noted "limited interdisciplinary and global perspectives" in the curriculum and pointed to a single EJ elective course as the only opportunity to explore this critical material (Schusler et al., 976).

In addition to a lack of EJ content in STEM-oriented environmental and sustainability degree programs, there are also complex relationships with and interpretations of diversity and inclusion, which creates a ripple effect on the ecosystem and pipeline into these career areas. Within IES programs, BIPOC students have reported feelings of isolation and exclusion, and

lack of representation of diverse faculty and staff (Schusler et al., 976), and other research has shown a nuanced relationship between the the enrollment of students of color and EJ content knowledge (Carlos Garibay & Vincent, 10), showing that underrepresented students may be more likely to choose environmental majors if there was more focus on EJ content, approaches, and career pathways. The research within STEM education in IES programs is consistent with work that has shown serious problems with diversity in STEM programs overall, and in engineering spaces (Peixoto et al., 2071), computing education and careers (Washington, 213), and a proclaimed "diversity crisis" in software development (Albusays, 19).

Along with issues in IES programs and tech education, there is a continued lack of diversity in environmental organizations, where although some gains have been made in gender, racial diversity is still troubling (Taylor, 4; Taylor, 6; Walter, 220). The tech career space also mirrors this problem, where Black and Latinx workers are underrepresented and those who enter these careers face numerous racial biases and barriers. These racial biases include: "isolation, questions about their competence, and racial microaggressions" (Alegria, 6; Brown et al., 146; Carter-Sowell, 399). In addition, although Asian workers are not statistically underrepresented, immigration policies, and "stereotype driven biases" block full participation in decision making (Alegria, 1). Alegria points out that these problems are critical to address in the tech development and innovation process as "technological products reflect this lack of diversity in ways that further disadvantage communities of color" (1). A lack of diversity is not just a problem of equity and access within educational and career pathways, but also a dangerous problem that can cause and perpetuate harm on minoritized groups across the globe, where worsening climate change can also exacerbate these issues.

The oversight of EJ in environmental, technology and general STEM educational contexts is problematic because it perpetuates the notion that technological advancement is inherently objective and value-neutral, ignoring the socio-political contexts that shape tech innovation and its impacts (Lance, 6; Mcgowan & Bell, 98; Ottinger, 81). There is an increasing body of research on EJ and climate justice (CJ) in STEM disciplines within higher education in general (Doucette et al., 8; Polk & Diver, 2), and in more specific disciplines, such as chemistry (Aoki et al., 283; Gerden et al., 4316) and engineering (Martin et al., 742), but there remains a significant gap in the literature addressing EJ in tech-specific education. This gap raises the critical question: How can we expect students to sufficiently address these undeniably socio-technical problems impacting society and the environment if they do not, at a core level, engage with an environmental justice framing? Without this lens, even well-intentioned technical solutions risk creating additional problems.

Educators may face a number of dilemmas when embedding environmental justice principles into environmental education, particularly when balancing established STEM approaches with the need to introduce complex social and ethical considerations. These challenges may include reconciling the epistemology of rigid institutional curricula that prioritize abstract technical skills rather than applied social engagement, and navigating resistance from both colleagues and students who may view justice-oriented education as sitting firmly outside the purview of STEM disciplines. Yet, the ethical responsibility of addressing these dilemmas is critical for developing technologists capable of tackling global challenges in an equitable way.

Similarly artificial intelligence and machine learning have immense potential to tackle complex environmental challenges, but can also amplify existing biases and power asymmetries if equity is not centered in their development and deployment (Rakova et al., 2). This article aims to fill this gap by arguing for the integration of an EJ framework in tech education. By empowering students with the critical thinking skills needed to examine the social and political dimensions of their technical training, we can cultivate a generation of technologists and innovators equipped to create a more inclusive, equitable, and just technological landscape. Only by wedding technical skills with an environmental justice mindset can we hope to devise true solutions to the pressing socio-technical challenges of our time.

In this article, we define technology as "a system created by humans that uses knowledge and organization to produce objects and techniques for the attainment of specific goals" (Volti, 6). Building on Volti's definition, we also refer to the application of scientific knowledge for practical purposes, including the development of tools, machines, and systems. This definition encompasses science and engineering as integral aspects of technological development, highlighting the interconnectedness of these fields in addressing environmental and social issues. By embedding an EJ framework into tech education, we can better address the systemic inequalities and historical contexts that shape environmental issues, fostering a generation of scientists, engineers, and practitioners committed to co-creating just and sustainable futures.

The integration of an EJ framework in tech education is crucial for several reasons:

1. **Understanding Root Causes**: Environmental injustices are not merely accidental byproducts of technological progress; they are often systematically engineered. Historical and ongoing practices in technology development are deeply embedded in colonialism, capitalism (Faber et al., 1), and systemic social oppression (Martinez & Gupta, 2-3; Ribot, 60; Stephens, 83). For instance, the mining of minerals for electronic devices often involves exploitative labor practices and severe environmental degradation, primarily affecting communities in the Global South (Rodríguez-Labajos, & Özkaynak, 245). By integrating an EJ framework, tech education can help students understand these root causes and challenge the systemic inequities perpetuated by technological practices.
2. **Addressing Disparities**: Technological development processes such as mining, manufacturing, and disposal disproportionately impact marginalized communities. For example, the improper disposal of electronic waste (e-waste) leads to toxic exposure and health problems in low-income and minority communities (Pellow, 490). Additionally, data storage facilities, which are essential for the digital economy, consume vast amounts of energy and water, often impacting local ecosystems and communities (Monserrate, 2). An EJ framework highlights these disparities and encourages students to consider the social and environmental impacts of their work.
3. **Fostering Inclusion**: Tech education has historically been exclusive, with a lack of diversity in both content and student composition. Incorporating an EJ framework is one way to challenge the exclusive, Eurocentric, and male-dominated culture of tech education, including addressing the systemic barriers such as racial microaggressions, immigration policies, and isolation (Alegria, 6; Brown et al., 146; Carter-Sowell, 399) that prevent diverse students from entering and succeeding in tech fields.
4. **Enhancing Community Engagement**: Meaningful community engagement is a cornerstone of the EJ framework (Cachelin & Nicolosi, 491; D'Arcangelis & Sarathy,

97). By building genuine partnerships with communities affected by technological decisions, tech education can ensure that these communities have a say in tech development and implementation. This engagement fosters more inclusive and equitable technological solutions.

5. **Demystifying the Tech-Non-Tech Binary**: The dichotomy between technical and non-technical aspects of environmental studies is false. There are no purely technical problems or purely non-technical solutions, especially when it comes to climate and environmental issues. By recognizing that all problems are socio-technical, we can better address the complexities of environmental justice and technological development. In fact, a recent engineering education article explores the development of socio-technical knowledge as a key strategy for broadening participation in engineering. Mcgowan and Bell ask: "How can we design learning environments to help students critically understand the intrinsic and systemic sociotechnical relationships between people, communities, and the built environment?" (981)

Through this article, we present a working framework for integrating EJ principles into tech education, focusing on areas such as active inclusion, centering diverse ways of knowing, community engagement, and changing the tech education ecosystem. By shifting pedagogical narratives and creating a culture of critical engagement, we can cultivate future leaders equipped to develop technology that advances environmental justice.

As authors, we acknowledge that our perspectives are shaped by our own backgrounds in engineering education, environmental justice, and policy. Our motivation for this work stems from a desire to challenge the often apolitical and ahistorical framing of technology use in environmental curricula and to advocate for more just, inclusive practices in environmental education. We emphasize the need for a more just, inclusive approach to teaching and learning in STEM fields, particularly when it comes to critically interrogating the intersection of environmental justice principles, and lack thereof, into STEM education development and deployment, with a particular focus on STEM-centered environmental education. We bring lived experiences of centering diverse ways of knowing and being in EJ education, and a deep desire to transform how we teach future leaders about the intersections of environmental knowledge, equity, and justice. We also recognize the need for continuous self-reflection in this work, particularly regarding how our own positionalities, biases, and perspectives shape the frameworks and interventions we approach.

Proposing an EJ + Tech Pedagogical Framework

Environmental injustices are intricately linked to the ways technology is developed, deployed, and maintained. The integration of an Environmental Justice (EJ) framework within tech education is critical for addressing the deep-seated inequities that technology can perpetuate. This section first outlines previously existing theories and frameworks that are in the EJ and STEM areas. Then, we review the core components of the EJ+Tech framework, emphasizing the importance of active inclusion, centering diverse ways of knowing, community engagement, and transforming the educational ecosystem. Additionally, it underscores how environmental injustices are engineered through historical and systemic practices, and how addressing these requires a fundamental shift in how we approach technology and education.

Theoretical and Conceptual Framework

Although EJ in tech education is an emerging area, there is a long history of EJ education research that spans decades. Theory and empirical research from Dorceta Taylor has focused on EJ as a culturally relevant framework for environmental education (Multicultural Env. Education, 3), and reviewed diversity among students (Diversity & Env., 89) and faculty (Faculty Diversity, 385), as well as attempted to understand student racial and ethnic differences in perceptions of nature (Perceptions of Nature, 118). More recent research on EJ education has focused on the critical role of community engagement (Cachelin & Nicolosi, 491; D'Arcangelis & Sarathy, 97). In addition to early research on environmental justice education, the Principles of Environmental Justice (People of Color Environmental Leadership Summit, 1991) also serve as foundational guideposts to our pedagogical framework. In general, t he p rinciples call for equitable public policy, responsible use of land, universal protection of environmental pollution, self determination of all peoples, equal participation of all groups, the need for regenerative urban and rural policies, and education among various other actions that help undergird our proposed EJ and t ech pedagogical framework.

More specific to the EJ and STEM content, this article heavily draws upon two recent articles that present more comprehensive frameworks and arguments for using EJ as a critical framework for teaching STEM or general science. First, we are influenced by Polk and Diver's discussion of how an EJ frame can be used for more inclusive science communication (3). These authors develop three EJ strategies for equity framing, which ask science students and communicators to: "(1) become aware of their own positionality and partial perspectives, (2) name sources of inequity that arise from uneven power relations, and (3) find intersections with initiatives that are rooted in the experiences of disadvantaged communities." This work provides a helpful scaffolding for both instructors and students for viewing all science work (but mainly communication and dissemination) as linked to historical inequities and uneven power dynamics between communities, both critical components to EJ.

In addition, we are inspired by the work of Doucette et al. that uses STEM as a key context for teaching climate justice (6). This work originates from an NSF funded project entitled: Climate Justice in Undergraduate STEM Incorporating Civic Engagement (C-JUSTICE). Within their discussion of this work, the authors review a culturally responsive approach to teaching STEM through the intersection of social justice and climate impacts, and poignantly argue that climate justice creates a meaningful, engaging, and socially just frame for delving deeper into specific STEM content areas.

In addition, the authors argue that providing a climate justice framework within STEM courses provides a context for real world issues that are more connected to students' interests, experiences, identities and communities, especially students who come from EJ communities. This process can aid students in better understanding more abstract and often decontextualized STEM course content. Finally, these authors argue that it is paramount that students are given opportunities for civic engagement in many different forms, which is highly connected to our argument that community engagement is a critical aspect of the EJ and Tech pedagogical framework.

Based on current and historical literature in EJ education, and these two more recent and relevant pieces using EJ and CJ as frameworks for STEM education, we propose our pedagogical framework for EJ in tech education below. It is first shown in Figure 1, and then we describe the framework moving from the top to the right in a clockwise direction.

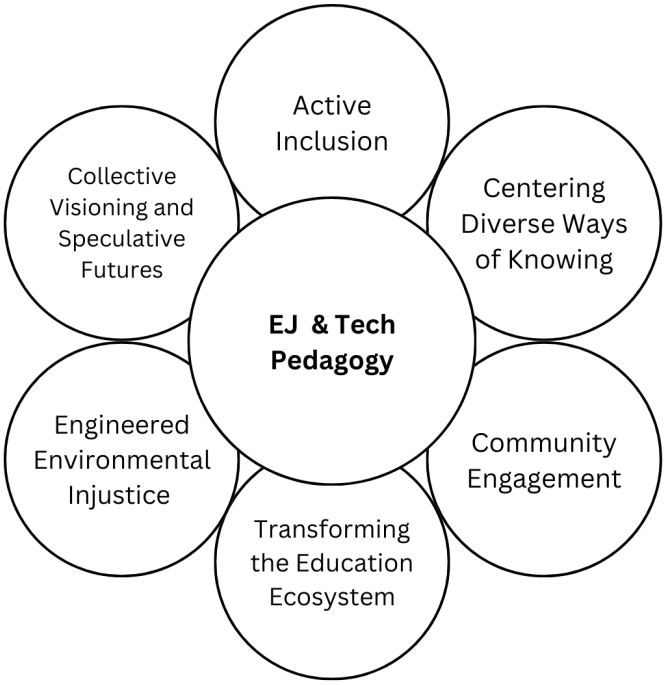

Figure 1: A Proposed Framework for EJ+Tech Pedagogy

Active Inclusion

Active inclusion is a fundamental principle of the EJ+Tech framework. It requires a critical examination of who is involved in the creation and implementation of technology and infrastructure, and how these decisions are made. Historically, technological development has been dominated by a narrow demographic, often excluding marginalized communities from decision-making processes (Alegria, 1; Ottinger, 81). This exclusion leads to the perpetuation of technologies that do not serve, and often harm, these communities.

To achieve active inclusion, we propose that tech education should:

Diversify Participation: Studies within Interdisciplinary, Environmental, and Sustainability (IES) degree programs and within sustainability degree requirements have shown both a lack of EJ content integration (Garibay et al., 933; Coleman & Gould, 229), and reports of isolation and exclusion among BIPOC students (Schusler et al., 976). A follow up study from Garibay and Vincent (1) reviewing data from 343 IES programs found that programs with a more inclusive curriculum (containing EJ content and programming for community engagement) and a diverse study body, were more likely to see an increase in student compositional diversity over a five-year period. These findings combined with Garibay et al. (933) highlight the important role of actual EJ-related content knowledge in the curriculum and programmatic

presentation of the curriculum play in diversifying the participation of a program over time, as they state: “What is included or excluded in the curriculum communicates to students what or who is and is not valued.” (Garibay and Vincent, 12).

These findings connect well with Schusler et al.’s study of two IES programs in the midwest that included twenty four interviews with BIPOC students (976). Overall, these findings revealed that BIPOC students identified gaps in interdisciplinary and global content, as well as content linking social and ecological issues. They noted that topics addressing the impact of environmental science issues on different racial or ethnic groups were only covered in a single environmental justice elective. Interviewees expressed feelings of isolation and exclusion motivated by a lack of discussion on race and experiences of discrimination. Student participants also reported that support networks, extracurricular engagement, and BIPOC- specific activities helped improve sentiments of belonging. This research connects with earlier theory (Taylor, 3) that explains that the way environmental curricula and program content is communicated to BIPOC students, low-income groups, or other students from EJ communities matters in terms of diversifying the ecosystem of students matriculating into environmental-related programs.

In line with these studies, we recommend various actions to diversify the participation of an environmental program or course with a technological or broader STEM focus. As Garibay & Vincent note, it is critical to work on recruiting a more diverse study body, while also simultaneously (and continuously) working to diversify the core epistemology of a program. (12) This involves recruiting faculty and instructors who bring an environmental justice perspective, along with personal experiences, teaching expertise in environmental justice, and established relationships with community partners. Program leaders can create initiatives, workshops, and other professional development opportunities for faculty aimed at generating new consensus in the integration of EJ- related content knowledge and novel pedagogical practices like community engagement. In addition, programs could seek to build community partners integrated throughout differing programmatic elements to ensure a long-term, and more integrated component of community engagement as Gariaby and Vincent howed this variable is related to an increase in student diversity. (12)

In relation to Shusler et al. 's findings, extracurricular opportunities and BIPOC specific opportunities are helpful in increasing sentiment of belonging, which has an impact on student learning and retention. (976) In addition, programs could work intentionally to include EJ across the curriculum within multiple courses and modules as opposed to a more peripheral inclusion in one elective course. Prep-program internships that focus on BIPOC engagement and EJ-oriented issues could also support creating new content and building new recruitment processes and pipelines. Many of these strategies are much more important in tech- related or STEM-centric programs where the integration of EJ-related content knowledge or the application of extracurricular activities is less common (Garibay et al., 933; Coleman & Gould, 229). For this reason, it is even more paramount that program leaders and instructors think through these components to work on diversifying the overall participation both inside and outside of the classroom.

Center Inclusive and Participatory Design: Teach students to design technologies that are inclusive and equitable, taking into account the needs and perspectives of diverse communities. Educators have a critical ethical responsibility to challenge the dominant technological

paradigms that, by prioritizing profit and efficiency, often exacerbate social inequality and environmental harm. These paradigms tend to reinforce systems of exclusion, where marginalized communities are left out of technological decision-making processes and bear the brunt of harmful environmental consequences, as seen in issues like e-waste management and extractive industries (Pellow, 2020). By embedding environmental justice into environmental education, students not only gain a broader understanding of the intersection between technology and justice but also develop the critical thinking skills necessary to identify and challenge the systemic inequalities embedded in technological development. This exposure equips students to actively participate in creating more equitable systems and technologies, ensuring that future innovations do not perpetuate the same harms but instead serve to dismantle oppressive structures. Similar to the above case study, this design process would encourage students to take a diverse set of communities' lived experiences into account as fundamental aspects of the technological design process, and defer to community members as key decision makers. This approach is often referred to as *participative design* which stems from frameworks such as Participatory Action Research (PAR) (Baum et al., 84), inclusive innovation, and design justice (Costanza-Chock, 530). A cornerstone of these practices is allowing community members to clearly articulate a particular problem they are faced with, and co-create designs with their needs and capacities centered in the process.

An important dimension of participatory design that aligns with environmental justice principles is appropriate technology, which emphasizes developing tools and technologies that are culturally, economically, and environmentally suited to the specific contexts in which they will be used. (Buitenhuis et al., 1). Appropriate technology approaches are often characterized by small-scale, locally managed, and sustainable innovations and complement participatory design by ensuring that technological solutions are not only co-created with communities but also tailored to their local contexts.

Key aspects of this design process are to build relationships with community members and create sustainable, reciprocally beneficial partnerships that focus on long-term goals. Appropriate technology supports these partnerships by fostering solutions that are not only technically sound, but also aligned with social and environmental goals and realities (Sianipar, 8).

Center Diverse Ways of Knowing: The EJ+Tech framework recognizes that traditional Western scientific paradigms are not the only valid ways of understanding and interacting with the world. Indigenous knowledge systems and other actively marginalized epistemologies offer valuable insights that are often overlooked in mainstream STEM education. As such it is also paramount to value other epistemic perspectives by encouraging students to appreciate and respect different ways of knowing and understanding the world. This can be achieved through case studies, guest lectures, and collaborative projects with communities that hold these knowledge systems. Guest lectures from diverse individuals working in the field provide extremely valuable insights of real-world knowledge and critical representation for students from underrepresented backgrounds. By centering these "othered" ways of knowing, tech education in environmental education contexts can become more holistic and inclusive. We recognize that educators may encounter resistance from both students and external stakeholders when presenting these perspectives. This pushback is likely rooted in the widespread belief that science and technology are objective and value-neutral disciplines (Lance, 6; McGowan & Bell, 98; Ottinger, 81). However, while introducing alternative epistemological frameworks and

environmental justice considerations may be perceived as overly political, it is important to note that the omission of these frameworks is itself a political act.

Critique and Explore Knowledge Systems: To center diverse ways of knowing, tech-centered environmental education should critically examine the dominance of Western scientific paradigms in tech education and highlight the contributions of non-Western knowledge systems. Programs and courses interested in centering diverse ways of knowing should consider first reviewing the origins and deeply problematic aspects of Western and or Eurocentric epistemologies, and then review ways of knowing that may not be traditionally included in a technologically oriented disciplinary space. To provide a framework for critiquing Eurocentric epistemologies, Rendón in her work *Sentipensante* (2009) develops several agreements such as intellectual/rational knowing, separation, competition, perfection, avoiding self-examination, privileging outer work, and monoculturalism to explain how teaching and learning are often governed by unspoken Eurocentric rules that disconnect learners from the material, devalue emotional, spiritual and social knowledge, and assume a linear, competitive, perfectionist progression of learning (26). Rendón contrasts these agreements by explaining how other ways of knowing such as Indigenous knowledge, spiritual traditions, knowledge systems from the Global South and decolonial knowledge by contrast value socio-emotional ways of learning, iterative and cyclical learning processes, and deep connections between teacher, learner and community. (26) As such, a pedagogical methodology could draw upon Rendón or other scholars for this epistemological critique and exploration.

Recent literature in environmental and climate justice education both inside and outside of STEM contexts provides some strategies for implementing the above pedagogical methodology that involves critique of Western knowledge, and subsequent exploration of alternative ways of knowing (Cachelin & Nicolosi, 491; Rabe, 161). In a study of one, small environmental justice program and practices of one instructor, Rabe explores what the instructor calls "resistance and re-envisioning." (161) Similar to what is mentioned above, this instructor begins the semester by utilizing literature and activities that provide various critiques of Western ways of knowing, then, in various "trajectories" listed in the syllabus, they explore decolonial field methods which are described by Thibinathan and Kinsella as a form of "critical pedagogy" that "consists of transforming our colonized views and holding alternative knowledge." (1)

As part of the exploration of decolonial methods, the instructor engages in activities that seek to use the body as a key form of knowledge production with lessons focused on movements and senses such as "feel, listen/tell, sense, taste" and even "paddle." The goal is to help students experiment with alternative modes of knowledge interpretation *and* production (Rabe, 164). As such, instructors interested in centering diverse ways of knowing should actively engage in knowledge critique and exploration as they think about and design their syllabus. However, implementing a pedagogy of epistemic resistance will not come without potential pushback from program stakeholders, whether that be students, administrators, other instructors or institutional leaders. As Rendón poignantly explains, most learning within higher education operates under the governance of implicit or explicit rules and guidelines stemming from Eurocenric beliefs and values. (26) From this lens, educators interested in this critique and exploration methodology should anticipate the highly political nature of this work.

Engage in a Syllabus Audit: It is important for instructors or program administrators new to this area to first review their syllabus (or program syllabi) to gain insight into what kinds of knowledge and or pedagogical activities are already covered, and how they may contain Eurocentric biases, and a potential lack of diverse ways of knowing. Then, through a process of change, instructors or administrators can work to integrate more diverse ways of knowing and teaching within courses. In fact, work within design justice, social justice, computing, anti-racist teaching, and social work education discusses the level and scope of integration of justice and diversity related content and pedagogical approaches by engaging in course or syllabus audits (Hong & Hodge, 214; Feasler et al., 289; Teasly et al., 608; Vesely et al., 943). The study most relevant to our proposed pedagogical framework for EJ+Tech included an analysis of syllabi at a technical institution across design courses on how equity, ethics, and justice content and pedagogies were included across departments. This study was conducted to develop strategies for incorporating design justice into the broader field design education. According to the Design Justice Network, "design justice is a framework that explores how a designed artifact distributes benefits and burdens to various groups". The study included both engineering and non-engineering departments and spanned 240 courses where a total of 336 recommendations were compiled from departments and were categorized into 10 themes; pedagogical strategies were also presented in the discussion.

This study demonstrates that a large-scale syllabi audit for equity, ethics and justice is a reasonable and actionable strategy for evaluating, and creating change within course design across departments and potentially other institutional contexts. In addition, an important result from this kind of audit process is to consolidate best practices in the form of curricular and pedagogical recommendations. Quite relevant to our current framework for EJ pedagogy, this study highlights nine recommendations for design justice pedagogy displayed in Table 1 below.

Design Justice Pedagogical Strategies		
1. Change course layout to engage with design justice topics.	2. Embed topics on the societal impact of technologies.	3. Engage with ethics assessment of designed technologies.
4. Emphasize communities and practice responsible engagement with communities.	5. Discuss real world applications of technologies and their consequences and effects.	6. Engage with topics around sustainability.
7. Support reflexivity and empowerment in technology design.	8. Be aware of the systems and context surrounding technology design.	9. Recognize examples of successful engagement with design justice.

Table 1: Design Justice Pedagogical Strategies (Adapted from Ostrowski et al., 7-9)

However, although the above studies explain roughly how to conduct syllabus, course, and departmental audits, little information is explained about how instructors or program directors can engage in informal, personally motivated audits that are specifically related to centering diverse ways of knowing. Below, we include questions that could help guide a knowledge-based course audit:

- Is the primary knowledge covered derived from Western and Eurocentric authors, readings and perspectives? Why?
- Who (authors/speakers/examples from what background) are represented?
- Where are their opportunities to include more diverse ways of knowing?
- How do students engage in learning? What are the key ways knowledge is communicated? Through reading and lecture? Or through guest speakers and site visits in the community?
- Are there opportunities for students to produce new knowledge through theory building, design, and building of new products or technology?

As such, we recommend engaging in syllabus evaluation as a key strategy for centering diverse ways of knowing and moving towards a framework for EJ+Tech pedagogy.

Elevate Indigenous Knowledge: Elevating Indigenous and other marginalized knowledge systems in the curriculum is essential for creating a more robust approach to environmental education. However, it is important to acknowledge that Traditional Ecological Knowledge (TEK) and Western Science are distinct systems of knowledge, each with their own methods, values, and cultural contexts. We suggest that educators should emphasize the complementary nature of these approaches in robust environmental pedagogies.

As Whyte argues in *Indigenous Climate Change Studies: Indigenizing Futures, Decolonizing the Anthropocene* (2017) Indigenous climate change studies highlight the deep collective histories that Indigenous peoples have in adapting to environmental change, alongside the reality that anthropogenic climate change is an intensification of colonially induced environmental disruptions. Whyte emphasizes that the same colonial, capitalist, and industrial forces that displaced Indigenous peoples from their lands are now driving climate change. He argues that climate change is not a new threat to Indigenous communities but rather a continuation of the disruptions caused by colonization (Whyte, 154-155)

Whyte also highlights the importance of renewing Indigenous knowledge systems to mobilize communities toward self-determined climate change planning. This renewal involves restoring relationships with nonhuman relatives and ecosystems—what Whyte calls "renewing relatives"—which strengthens the capacity of Indigenous communities to address climate change on their own terms (Whyte, 158).

Melissa Nelson builds on this by emphasizing the epistemological sovereignty of Indigenous knowledge systems, arguing that they are embedded in worldviews and practices that differ fundamentally from Western ways of knowing. She advocates for a cognitive decolonization, urging academic programs to move beyond Eurocentric frameworks and embrace indigenous epistemologies and methodologies as legitimate and vital sources of knowledge. Nelson calls for education to recognize Indigenous systems, not as alternatives to Western knowledge, but as

powerful, sovereign intellectual traditions with their own methods of producing knowledge and stewarding the environment (Nelson, 40).

By bringing TEK into the classroom, students can engage in discussions around epistemic diversity and justice, exploring how Indigenous approaches to knowledge, adaptation, and environmental stewardship differ from and complement Western science.

The inclusion of TEK in the classroom provides a pathway for students to explore epistemic diversity and justice. Discussions of TEK should encourage students to reflect on the power dynamics that shape knowledge production and to recognize that Indigenous knowledge systems are not supplementary to Western science but rather parallel systems of knowledge that hold their own authority and validity. Introducing these concepts allows students to grapple with the historical and ongoing marginalization of Indigenous peoples and knowledge, while exploring how alternative ways of knowing can address the harms caused by technology and innovation.

For more resources and examples of how to foster meaningful collaborations between Indigenous knowledge systems and Western science, educators can refer to the work of the *Center for Braiding Indigenous Knowledge and Science (CBIKS)* at the University of Massachusetts, Amherst. CBIKS offers insights into how these systems of knowledge can engage in productive dialogue while maintaining their distinctiveness and integrity.

Given that TEK and other diverse ways of knowing are still underrepresented in tech-focused educational spaces, educators will need to scaffold this process for students. One effective approach is to begin the course with a critique of Eurocentric knowledge in academia, exploring the limitations and biases that have historically shaped technological innovation. This critique can include a review of how technologies have disproportionately harmed marginalized communities. From this foundation, students can explore how Indigenous perspectives, like those rooted in TEK, offer valuable alternatives for addressing these past and ongoing harms. By fostering a learning environment that values epistemic diversity, students are encouraged to think critically about how different knowledge systems contribute to a more just and sustainable future.

Community Engagement: Meaningful community engagement is essential for ensuring that technological development is equitable and just. This involves building genuine partnerships with communities affected by technological decisions and ensuring that they have a voice in the process. It is also important to note that work in the area of EJ teaching and learning in higher education has pointed to community engagement as a common strategy used (Cachelin & Nicolosi, 491; D'Arcangelis & Sarathy, 97; Doucette et al., 6), and is associated along with EJ content knowledge as having a relationship with student of color enrollment in IES programs (Garibay & Vincent, 8).

EJ Education and Community Engagement. Research demonstrates EJ education is intricately connected with community engagement due to the EJ movement and field of study's focus on confronting how specific communities understand and address inequitable environmental dilemmas (Cachelin & Nicolosi, 491; D'Arcangelis & Sarathy, 97; Garibay & Vincent, 8). For example, one study focused on critical community engaged EJ instruction at a predominantly White institution (PWI) where students worked on two separate community-

engaged learning projects, the Indigenous Energy Sovereignty research project and the Salt Lake City Bicycle Collective. In an analysis of 25 student course reflections, findings showed that students demonstrated learning around four themes: 1. Systems thinking, 2. Place, 3. Positionality, and 4. Agency. Most importantly, students within this PWI context were able to see systems and structures that maintain environmental racism, and were able to articulate their own positionality in the process (Cachelin & Nicolosi, 491).

This is consistent with other research that has argued that community-engaged partnerships can give educators opportunities to "combine theory with practice and disrupt students' assumptions about what or who constitutes the environment " and allow students to "re-evaluate and reframe their political and theoretical commitments and carve out meaningful ways to contribute to environmental justice work." (D'Arcangelis & Sarathy, 97). As mentioned above, Garibay and Vincent (8) also show that community engaged practices within IES programs are associated with improved racial climate, which may lead to increased diversity within these programs. As such, community engaged learning is beneficial in a number of ways in environmental justice educational contexts.

Much more work needs to be done to better understand how this kind of community engagement can work in courses and programs that are much more tech focused although Doucette et al. explain that civic engagement is a critical component of teaching STEM through a climate justice framework. (6) Without opportunities to engage with community and real-world issues (even in STEM contexts), students are left knowing the problems but are unable to meaningfully participate in their solutions. However, this research is often focused on students, and not impacts on the community, or on the processes of relationship and project development. For this reason it is also critical to think about how community engagement can work and should work in actual practice.

Community Engagement in Practice. If instructors or program leaders are interested in getting involved with community engagement practices, they should think very carefully from the onset about how to build long-term, reciprocally- beneficial relationships where community partners have full participation in the research process and also either co-own or fully own data and/ or project deliverables. Key instructional practices include building partnerships, incorporating community feedback, compensating community time and work, as well as scaffolding student interactions with partners. Although there are many instances of successful academic-community engagement, there are many where the more powerful (often academic) institution does not fully listen to the community's knowledge, voices or experiences. Ottinger refers to this as epistemic (in)justice, and points out how in even seemingly successful community partnerships, problems encountered by the community partner include exclusion from judgment, inadequate epistemic resources (especially in regards to a mismatch in knowledge-based resources between academic and community organizations) and denial of status of knowers. (199)

In response to this, Ottinger (proposes the concept of careful knowing, which refers to "practices of empirical investigation and meaning-making responsive to the needs of marginalized knowers, as a remedy for epistemic injustices that occur in EJ settings."(199) More specifically, careful knowing is intricately tied to relationship building where caring relationships are naturally asymmetrical, where power relationships are thoughtfully negotiated between the cared-for and

caregiver. When caring for someone, it is virtually impossible to do a good job without intimate knowledge of what they need and what they suffer from, and also recognizing the limits of one's own capacity to care. Along with Ottinger's (199) concept of epistemic injustice within EJ related partnerships, there are also many other nuanced challenges within organizations of higher education to account for.

For example, some challenges include a lack of incentives (especially in the tenure-track process) for instructors or faculty, difficulty in ensuring both student learning, and contributing final projects to community partners (scaffolding for students), lack of funding to compensate community partners, and an increase in time and labor required in this kind of teaching. It is important for instructors to attend workshops or training on community engagement, and approach a community-partnership course design with early preparation, detail and care. This should be combined with seeking out and garnering both departmental and institutional support for this kind of practice (Mchugh et al., 82).

Training also aids instructors in understanding the history of higher education's role in creating extractive, or transactional relationships with community partners, which is sometimes referred to as "parachuting or helicopter science" (Balazs & Morello-Frosch, 10; Mchugh et al., 82; Mitchell, 50), which may cause partners to be more hesitant in engaging in new projects. If instructors are new to this kind of practice, it can be helpful to start small. This means attending events at a local community organization and building relationships first before discussing any kind of partnership or starting with smaller scale activities such as inviting guest speakers to the class and short site visits or informational sessions in a community organization's space to feel out how a larger-scale partnership could work.

In regards to relationship building, recent research that seeks to create a framework for "justice-centering relationships" within community engaged pedagogy describes how relationships are critical to further other impacts such as "repairing and rebuilding trust, [providing] access and inclusion, and [managing] power dynamics" (Quan, 148). In addition, community partners "[see] relationships as the impact they [are] ultimately seeking." (Quan, 148) More specifically, one such relationship dynamic described was that "colleges and universities recognize their place, roles, and responsibilities as part of the community rather than apart from it " (Quan, 150). From this lens, long-term, critical, and mutually beneficial partnerships can also play a role in transforming the way knowledge is produced and in the relationship between academia and community, which has not been thoroughly explored within the context of tech education.

Transforming the Education Ecosystem

The current tech education ecosystem is highly exclusive, predominantly white, male, Eurocentric, and affluent. This lack of diversity perpetuates a narrow perspective on technological development and limits the potential for innovative and equitable solutions. As such, systemic changes are necessary both inside and outside the classroom that can create new cultures, practices, curricula and pedagogies that rewire how tech education has historically functioned. A new kind of tech education (especially in environmental contexts) is needed to better address the techno-social and techno-environmental dilemmas we face now and into the future.

To transform the education ecosystem, tech education should:

Address Systemic Barriers and Promote Equity and Inclusion: It is paramount to identify and dismantle the barriers that prevent marginalized students from entering and succeeding in tech fields. This includes addressing issues such as financial barriers, lack of mentorship, and discriminatory practices such as racial microaggressions or practices that block shared decision making among certain immigrant groups (Alegria, 1). Additional systemic barriers include exclusion from decision making and leadership positions, racial bias, lack of diversity, blocked pathways for development, and stereotype- driven biases, all which contribute to the process of biased design and innovation within the production process of new technologies (Alegria, 4-8). However, in some cases, Asian workers succeeded despite these obstacles, but not due to change in stereotypes or perspectives on diversity. Instead this was due to these workers creating transnational support and resource networks, while also building local professional networks, and new cultures within immigrant led silicon valley companies (Saxenian, 20; Shih, 177). With these obstacles in mind, stakeholders within educational institutions should inform themselves of these barriers within tech fields, and seek to build programs and partnerships with industry in attempts to alter some of these barriers.

For example, program leaders should implement and develop policies, practices, and programs that promote equity and inclusion within STEM and tech- specific education. More specifically, it is crucial to create targeted scholarships, mentorship programs, and internships. Across higher education, there are various initiatives and internship programs that have sought to transform the epistemic structure and pipeline ecosystem within STEM educational areas. One excellent example is The University of Massachusetts, Boston and Dana Farber Cancer Institute Partnership, an NIH grant funded project which seeks to challenge and transform both who has access to STEM-based cancer research careers, and reorient the research goals to better focus on the inequitable process and outcomes in cancer research (UMass Boston & Dana Farber Cancer Center Partnership). This program is innovative in that it focuses on both epistemic justice (how cancer research does not always include diverse and justice-based perspectives), and procedural or participative components (how the cancer research professional piple-line lacks diversity due to the many barriers mentioned above that are similarly pronounced in medicine).

Create Inclusive and Anti-racist Curricula: Another necessary area is to develop curricula that reflect the diverse experiences and perspectives of all students. This includes incorporating EJ principles and highlighting the contributions of marginalized groups (Kishimoto, 540) to technological development. This also requires tapping into research on anti-racist and inclusive teaching (Dewsbury & Brame, 1; Sanger, 31) across disciplines in higher education, and reviewing emerging areas specific to tech.

When engaging in programmatic, curricular and pedagogical changes, it is important to review some nuanced differences in terminology, and examine more specifically what inclusive or anti-racist teaching and learning encompasses. For example, Inclusive pedagogy is defined by Sanger as “an approach that aims to make learning as accessible and welcoming to all students as possible, ” w hich is critical for thinking about how to design learning experiences for students from different social, cultural, ethnic, racial, and gender backgrounds, as well as learners with disabilities or those who have special needs.(33) Sanger describes eight specific practices to implement inclusive teaching, which range from proactively learning about your

teaching environment, showing confidence in the potential of each student, creating explicit expectations, using varied teaching techniques and formats, practicing inclusive assessment techniques, avoiding projecting professional goals or learning preferences on students, representing diversity in syllabi and course content, and recognizing instructional power (37-59).

However, anti-racist pedagogy is specifically designed to confront systematic racism, and "not only uses the classroom to explore the effects of racism, but also recognizes the role of educational institutions, practices, and practitioners in producing and reproducing racial inequality" (Alderman, 187). Similarly, Kishimoto writes about anti-racist pedagogy in higher education and describes many different components of this kind of pedagogy, which include: critically analyzing instructor identities (self- reflexivity), rejecting positivist and objective thinking, challenging Eurocentric knowledge, analyzing power relations, creating awareness of student social identity, decentering authority in the classroom, challenging what and how the teaching and learning process happens, and building community through decentering authority and collaborative learning. (546)

From this lens, utilizing an antiracist approach for a course can be seen as a more overarching strategy that takes the institutional and departmental histories, culture and practices into account. In addition, antri-racist teaching practices can draw upon several other common pedagogical strategies, such as collaborative or peer learning, engaging in critical self- reflection, critical thinking about the history and nature of knowledge, and building community both in and outside of the classroom. Inclusive and antiracist teaching practices should be interconnected to other EJ+Tech pedagogical principles such as community engagement, valuing epistemic diversity and recognizing the history of engineered environmental injustice.

Engineered Environmental Injustice

Environmental injustice does not happen by chance; it is engineered through historical and systemic practices rooted in colonialism, capitalism, and social oppression. For example, the placement of toxic waste facilities in predominantly Black and low-income communities is a deliberate decision that perpetuates environmental racism (Johnston and Cushing, 48).

To address engineered environmental injustice, tech education must:

- Recognize Historical Contexts: Teach students about the historical and systemic roots of environmental injustice. This includes examining the roles of colonialism, capitalism, and other forms of social oppression (Martinez & Gupta, 2-3; Stephens, 2).
- Critique Capitalism: Encourage a critical examination of capitalist practices that prioritize profit over people and the environment (Faber et al., 1). Drawing on the work of scholars like Max Liboiron , students can explore alternative economic models that promote sustainability and equity. (331)
- Highlight Embedded Harm: Show how technological systems and infrastructures often embed harm in their design and implementation. This involves examining case studies of environmental injustices and discussing ways to redesign these systems to mitigate harm. Examples of globally oriented case studies could include: EJ implications of the industrial shipping complex in northeast Brazil (Meireles et al., 171), how mega urban

planning projects negatively impact indigenous communities in Panama (Joanna, 1), and displacement through modern development in urban renewal in South Africa (Massey, 265).

Along with the above case study examples, there is also an online open source resource known as the EJ Atlas, which was created to "to make visible and systematize contemporary struggles against environmental injustice worldwide with and for affected groups" (Walter et al., 101). Instructors can use this resource in dynamic ways, such as having students explore EJ case studies from particular regions and countries, review concepts and trends, model and practice case study research, and even identify and update the EJ Atlas with new and emerging EJ conflicts (Walter et al., 101).

Researchers have also described case study or case-based learning (CBL) as its own unique kind of pedagogical practice in teacher education (Darling-Hammond and Hammerness, 125) and in healthcare fields (McLean, 39). CBL shares some similarities with project-based learning and inquiry based learning where students can engage in the exploration of a defined narrative, historical process or project, or a dilemma that has a defined date, time, and place with boundaries. Case study or CBL can aid students to contextualize previously discussed abstract theory, connect theory with practice, engage in deeper learning, and practice critical thinking. In the specific case of EJ in tech education contexts, reviewing both current and historical cases can also support students in seeing the intersections of socio-political systems, such as colonialism and capitalism, technology and environmental (in)justice within different global and cultural situations.

Collective Visioning and Speculative Futures

To foster innovative and equitable technological solutions, tech education must move beyond traditional problem-solving approaches and engage in collective visioning and speculative futures. This involves imagining alternative futures that prioritize justice, sustainability, and equity.

To incorporate collective visioning, tech education must:

Encourage Creative Speculation: Encourage students to imagine different futures and explore speculative scenarios (Dunne et al., 89). This can involve exercises like imagining a just, equitable, and sustainable circular economy. Other scholars refer to this as creating systemic alternatives (Foran, 129). To provide one example already discussed in this paper, a critical intersection of tech and environmental justice can be explored through the lifecycle of electronic hardware, which entails extraction (mineral mining), manufacturing, disposal, and recycling. However, this topic is rife with complex and challenging material for students to grapple with. In addition, within more specific topics such as conflict mineral mining for electronic devices or human rights violations within electronic manufacturing, comprehensive solutions are underdeveloped, and it can be hard for students to truly imagine near-term changes to our economic system or governmental institutions that will catalyze change.

One engaging way to allow students to wrestle with these issues is for them to examine speculative futures with "what if" questions, and create "invitations to make believe" (Dunne et

al., 89). Dunne et al. describe this as creating props, or fictional narratives and situations that allow audiences or learners to get lost in make- believe scenarios. (89) For example, they state: "Props used in design fiction are functional and skillfully designed; they facilitate imaging and help us entertain ideas about everyday life that might not be obvious. They help us think about alternative possibilities, they challenge the ideals, values, and beliefs of our society embedded in material culture" (89). From this lens, instructors should attempt to draft and explore alternative futures with students using "what if statements," and allow students to engage in creative futurism and collective visioning in the classroom.

Engage with Complex Interventions and Emotions: Teach students to develop complex, interdisciplinary solutions to socio-technical problems. This involves understanding that there are no simple solutions and that addressing environmental and social issues requires multifaceted approaches.

In some cases, working with complex interventions involves helping students come to terms with issues that do not reach closure, especially during one academic semester or year. It is of vital importance to support students in grappling with complex emotions that stem from potential situations where our understanding of alternative futures are still evolving. In fact, over the last few years, there has been an explosion of research in environmental and sustainability education that seeks to better understand student and educators emotions (both in K-12 and higher education) in relation to climate change and environmental issues (Jaquette-Ray, 15; Ojala, 1109; Pihkala, 2; Verlie et al., 134). This work has explored definitions of various emotions (hope, eco-anxiety, and distress, for example) and tools for working with emotions in classroom settings. For example, Pihkala has written extensively about eco-anxiety, which he defines in many ways, but most generally explains that it is a "a general term for anxiety in relation to the ecological crisis" (2).

Pihkala explains that both educators and learners grapple with challenging emotions in relation to the climate crisis and provides several strategies for working with them. (20) For example, Pihkala reviews and discusses various classroom- based strategies and tools for working with eco-anxiety and other potentially distressing emotions. (20)These strategies are adapted and described in Table 2 below:

Strategies for working with eco-anxiety in the classroom	
Strategy	Rationale & Description
Self reflection	Develop resilience for working with emotions. Practice projecting emotions to students in responsible ways. Gain comfort in discussing emotions within classroom settings.
Validate emotions and emotional experiences	Important to recognize student emotional experiences; validation involves letting speakers know that you hear and understand them, and checks for correct

	interpretation. Educators can recognize the vulnerability or vast complexity of a particular issue.
Providing information about coping with eco-anxiety	Educators can attempt to gain some knowledge regarding eco-anxiety or climate distress, and provide information, strategies, and resources to students during lessons, modules or units.
Providing students with opportunities to discuss emotions	Researchers and psychologists support the benefits that are associated with discussing one's emotions in safe spaces. Providing opportunities for structured reflection and naming of one's emotions can be done within different contexts in the classroom. One potential activity mentioned is watching a video or reading a text with emotional examples and then naming the emotions within groups or full class discussion.
Engage in collective action	Some research points out that when students have the opportunity to learn about environmental justice issues and engage in community engagement, this can generate increased self-efficacy (Bartlett et al., 2023). In relation to the community engagement section above, providing spaces for students to engage with community members and real-world scenarios is important for students to feel like they can participate in societal change.

Table 2: Strategies for working with eco-anxiety in the classroom (Adapted from Pihkala, 20-26).

During a tech-centered course where particular environmental problems often occupy the focus of the class, providing a small space for understanding and naming the emotional complexities of this issue (at societal, organization or individual levels) could be a profound shift in pedagogy that can alleviate differing forms of climate distress or eco-anxiety among students. For this reason, we recommend some focus on climate and environmental related emotions as part of an EJ+Tech pedagogical framework.

Future Work/Recommendations

As we move towards building EJ frameworks to be integrated into environmental science education, particularly educational initiatives with a technology focus, it is essential to look towards future areas of growth. Several key areas for future work and practical recommendations for educators, institutions, and practitioners can deepen the impact of EJ principles in environmental tech education. While many efforts are already underway, there are key areas of future work and opportunities for innovation that remain unexplored.

Future Work

Expanding research and case study materials used in environmental syllabi is essential to explore the long-term impacts of integrating EJ frameworks in tech education. Additionally, creating comprehensive interdisciplinary curricula that blend EJ principles with technological education and developing teaching materials and resources highlighting the intersection of technology, environment, and justice are crucial steps, as is exploring the new intersections between emerging technologies and environmental justice that have not yet been comprehensively addressed, such as artificial intelligence and machine learning.

Continuing to undertake longitudinal studies to track the progress of diversity and inclusion efforts within tech education and measuring the impact of EJ-focused education on career trajectories and community impacts can provide valuable insights as pedagogies and access to education evolves. Furthermore, finding an appropriate balance between community needs and constraints, and student learning outcomes in partnerships with communities to co-create technological solutions and supporting community-led research and innovation projects that prioritize EJ principles are important future work areas.

Perhaps most importantly, while instructors can begin by implementing EJ principles in their classrooms, building both top down support from institutional leaders and bottom up support from students and instructors interested in this work is needed for systemic change to occur. Instructors or curricular change- makers interested in creating larger- scale change can implement changes into their own classroom but then advocate for change at the departmental, programmatic, and institutional levels. This multilevel advocacy ensures that EJ frameworks are not siloed or limited to elective classes, but become integral to institutional policies, curricula, and community outreach initiatives.

Recommendations for Practitioners

Practitioners should utilize available resources and tools, such as initiatives like The Rooted Futures Lab's work and the MIT Environmental Solutions Initiative's Climate Justice Instructional Toolkit, which provide open-source toolkits and resources for integrating EJ into tech education, while considering what new tools and methods are needed to advance this work. Interactive tools for advocacy, stakeholder assessments, and community engagement available through our platforms can be highly beneficial. Active inclusion and mentorship are vital; actively recruiting and supporting marginalized students through scholarships, mentorship programs and extracurricular activities designed for BIPOC students, and creating inclusive classroom environments that respect and incorporate diverse ways of knowing are recommended practices.

In addition, building genuine, long-term partnerships with affected communities, ensuring their voices are central to technological development, incorporating community feedback, and compensating community members for their contributions can foster meaningful community engagement. Encouraging students to critically assess the socio-political contexts of technological advancements and including historical and contemporary case studies that highlight the impacts of technology on marginalized communities can catalyze critical and reflective pedagogy.

Promoting interdisciplinary collaboration within educational institutions to bridge the gap between technical and non-technical fields and encouraging students to engage with environmental scientists, sociologists, and community leaders can enrich tech education. Teaching students participative design and inclusive innovation methodologies, using models such as participative design, inclusive design, or design justice to guide students in co-creating technologies with community members, is recommended.

Facilitating collective visioning by incorporating speculative and future-oriented exercises that encourage students to envision equitable and sustainable technological futures and supporting students in navigating the emotional complexities associated with systemic challenges and speculative futures are crucial.

Conclusion

In an era where technological advancements profoundly shape our environmental landscape, integrating environmental justice (EJ) into environmental education is a pedagogical necessity. In this article, we outlined the background and some methods to embed EJ principles within tech-focused environmental studies to address the systemic inequalities that underpin both technological development and environmental degradation. More specifically, we first described a multifaceted argument for why instructors and programs should include EJ, culturally relevant, and inclusive practices within the technology related environmental education spaces. Next, we proposed a pedagogical framework for EJ and Tech, which includes interwoven relevant literature, examples and recommendations. A final section reviews brief areas for future work and more high-level recommendations for educators.

By challenging the dominant societal and educational narratives that frame climate change and environmental issues as purely technical problems (Stephens, 1), we can cultivate a more robust understanding of the root causes and points of critical engagement in developing climate solutions amongst the next generation of environmental practitioners. The proposed EJ+Tech framework emphasizes active inclusion, the centering of diverse ways of knowing, meaningful community engagement, and a transformation of the educational ecosystem. Each of these components supports the creation of a more robust educational experience that better equips students to interface with the complex socio-technical challenges of our time.

As we look to the future, it is imperative that educators, institutions, and students work collaboratively to implement these changes. By fostering an educational environment that prioritizes EJ, we can cultivate leaders who are equipped to lead projects that advance environmental and social sustainability.

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