Social Equity Perspectives in Transportation Education

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Abstract

The idea of social equity is rooted in the idea that each person is equal and has inalienable rights. Social equity addresses the third E of sustainability after economic and environmental factors. Despite growing interest in social equity in recent years, it remains the least discussed concept in the field of sustainability in transportation. Many of the current transportation projects and infrastructure fail to adequately consider the fair distribution of benefits and costs, highlighting a gap in the implementation of researched social equity considerations and a lack of trained professionals on equity- related topics. This study is a preliminary step in the effort to close the training gap on equity-related topics in the preparation of engineering students. A survey with civil engineering, environmental engineering and construction management students was conducted to identify their views on how their respective fields relate to or contribute to social equity. Furthermore, interviews were conducted with six educators and practitioners to identify gaps in training that limit the ability of new professionals in the transportation field to address equity. This study uses thematic qualitative analysis and descriptive statistics to identify common themes and explore approaches, misunderstandings, and challenges in addressing social equity. On average, students rated the relevance of equity to their future practice in the built environment at 3.48 out of 5, with 60% expressing a desire to integrate equity into their academic studies and professional work. Practitioners emphasized the importance of active listening, effective communication, and openness to diverse perspectives, while educators highlighted the potential of community-engaged learning to enhance equity in transportation education. This study can help create a foundational framework for future researchers to explore deeper questions about how equity is understood and taught. It also provides insights into creating more inclusive educational strategies addressing diverse perspectives and learning needs.

1. Introduction

Social equity is commonly defined as fair distribution of benefits and costs [1]. In relation to civil engineering and transportation, social equity is reflected in terms of mobility, accessibility, travel time, safety, transportation expenditure, affordability, and investments. The usage of equity measures in planning and engineering is seen as implicit rather than explicit and can be covered by a variety of terms, such as social equity, social justice, or social exclusion [1].

Engineers design, create, and control the distribution of critical resources across society [2] and society is greatly impacted by the choices they make, especially when design decisions create

structural injustices. However, these impacts are often invisible to engineers, partly because they have not been considering the social consequences of their engineering decisions [3]. The likelihood of creating a more just society increases when engineers appreciate and strive for fairness [4]. Understanding the educational context and the importance of integrating equity issues is crucial to help engineers develop an equity ethic. However, the rigid and technology-focused nature of engineering education, rooted in meritocracy and a lack of political awareness, often prevents engineering students from exploring the social aspects of their field. To promote socially just engineering practices, we must change how engineering students are taught and equipped to address issues of inequality in the workplace. Like in many other professions, engineering culture and values may be imparted to students through belief systems that are discussed in more subtle ways rather than just fundamental courses [5].

There are few notable examples of civil engineering and engineering scholars incorporating approaches that do center social justice or at least include it in the preparation of future engineers [6]. For example, Turner et.al [7] founded the social justice in engineering design module to address the transformation of engineering practices in transportation engineering through integration of social justice in undergraduate civil engineering education. Furthermore, ABET criteria for Civil Engineering and related programs require the inclusion of principles related to sustainability, diversity, equity, and inclusion when addressing civil engineering challenges[8]. Additionally, it mandates that faculty possess adequate qualifications to provide effective guidance. The current educational strategies to integrate social equity principles into engineering curricula, however, are quite limited and might only include one required engineering ethics course [9]. Despite the efforts made to incorporate equity considerations into engineering curriculum, the disconnect of engineers towards the topic highlights a gap in between education and implementation.

This paper offers a preliminary exploration of civil engineering and construction management students' perspectives on how their fields relate to or contribute to social equity and insights from educators and practitioners about the shortcomings of engineering education in addressing social equity. Additionally, the paper examines how transportation can be used as an example context to bridge the gap between engineering and society and help students in transportation related fields develop a more comprehensive understanding of equity in their field.

2. Research Questions:

This study aims to gain an understanding of the current status of social equity education in civil engineering and construction to ultimately help improve educational content. To identify the

common misconceptions and difficulties in addressing social equity, this study is driven by the following research questions:

i. What are the existing challenges in incorporating and implementing social equity in engineering?
ii. How can social equity considerations be incorporated into engineering education?

3. Background

Engineers have an ethical responsibility to consider the social impact of their work, and this responsibility can be approached through various lenses, such as professional ethics or empathy. However, these concepts may mean different things to different people, leading to diverse interpretations and approaches to social responsibility in engineering. Many have attempted to incorporate social equity into engineering practices, employing various strategies to address its integration into education and practice. These approaches often involve navigating the disconnect between engineering and social justice [9], developing social empathy [4], and addressing ethical concerns related to social equity [4].

3.1 Engineering ethics:

Harris Jr. et al. [10] [11] described engineering ethics as standards for professional practice and highlighted it as part of thinking like an engineer. This concept of “thinking like an engineer” has since been criticized for not accommodating the social aspect of engineering [12]. Enhancing students' acquisition of ethical knowledge is one of the main objectives of engineering ethics education, [13] and eventually contributes to social justice. The comprehensive goals of engineering ethics education are outlined by Harris Jr. et al [10] and include fostering students' ethical imagination; identifying ethical issues; evaluating ethical concepts and principles; handling ambiguity; increasing sensitivity to ethical issues; and enhancing ethical judgment [10]. These objectives are essential for grounding engineering students in ethical decision-making behavior. To achieve these goals, engineering ethics curricula should balance professional codes, ethical theories, and real-world applications while taking social and cultural diversity into consideration [13].

3.2 Disconnect between engineering and social justice

Engineering and social justice are not always seen as compatible [14]. US engineers appear to be especially disconnected from concerns about how their job affects public welfare and generally avoid public discourse and policy development regarding the function of technology systems in society [15]. Cech [12] has identified a form of disengagement of engineering faculty and

students from concerns of social justice. The traditional exclusively technical emphasis of engineering education may make it particularly susceptible to this kind of disengagement [5].

Cech [12] identifies three ideological pillars associated with engineering culture that contribute to a behavior of disengagement to social concerns. These are 1. Technical/social dualism, defined as engineers' cognitive division of social and technical skills and their undervaluation of social skills, including those related to public welfare, 2. Meritocratic ideology, where success is believed to be a result of individual talent and where the way things are done is not usually questioned and 3. Depoliticization, the idea that social and political issues can and should be separated from engineering work because they may bias "pure" engineering practice.

3.3 Social Empathy:

Individuals can develop an equity ethic regardless of their social status; however, the process varies depending on one's social identity [4]. Research demonstrates that individuals can acquire social justice concerns after establishing social empathy, the ability to understand the experiences of diverse people, communities, and cultures [16]. To exhibit social empathy, social actors must show empathy toward individuals; a contextual understanding of the impact of systemic, historical conditions on communities; and a sense of social responsibility-what Segal [16] refers to as a “prosocial individual perspective that contributes to improving the larger social arena”.

Teaching social empathy to engineering students can be approached through motivation based on personal or shared lived experiences. Students who have historically been marginalized in engineering are more likely to adopt an equity ethic because they have experienced oppression and discrimination and can perceive inequality and social suffering in similar groups [4]. Unlike personal suffering, which is unrelated to social identity, this term refers to a group’s suffering “which inspires imagination of a ‘we’ who suffer” [17]. Those who identify their collective suffering as structural might cultivate social empathy by empathizing with their own group and other oppressed minorities, gaining a contextual awareness of unfairness, and feeling responsible for effecting change [4].

Exploring topics such as engineering ethics, the disconnect between engineering and social justice, and the development of social empathy reveals that each provides a unique viewpoint on how engineers might help to create a fairer society. Engineering ethics focuses on moral and ethical questions, ideas, and concerns, whereas the divide between engineering and social justice shows the difficulty in comprehending and addressing societal challenges. In contrast, social empathy aims to build a greater awareness of others' needs and experiences. Together, these

themes provide background and context for how social equity might be included in engineering education and practice.

4. Methodology:

In the first phase of this exploratory study, we surveyed first-year students in civil engineering, environmental engineering, and construction management to understand their perspectives on how their fields contribute to social equity. The survey included a mix of multiple-choice, open-ended, and ranking questions to collect both qualitative and quantitative data to address our research questions. We used Qualtrics to create the survey and collected responses from students. In the second phase, we conducted six interviews with professionals involved in equity work within transportation engineering and educators who teach equity concepts to engineering students. These interviews were conducted via Microsoft Teams, recorded, and transcribed. To ensure confidentiality, we removed all participant and organization identifiers from the transcripts before analysis.

The data collected from the interviews and survey were analyzed using the six steps of thematic analysis as outlined by Braun and Clarke, a method for identifying, analyzing, organizing, interpreting, and reporting patterns within qualitative data such as interview transcripts and survey responses [11]. Using this method, a data driven approach was taken to search for emerging themes. The process began with immersing ourselves in the material by reading through the transcript to become familiar with the data. We generated initial codes by identifying key aspects of the data that helped us understand the underlying patterns. These codes were then grouped based on shared meanings to create main themes that addressed the research questions. The identified themes were reviewed and refined by revisiting the earlier steps of the analysis. Finally, we clearly defined and named the themes that accurately reflected the data. The findings section provides an explanation of the identified themes from this analysis.

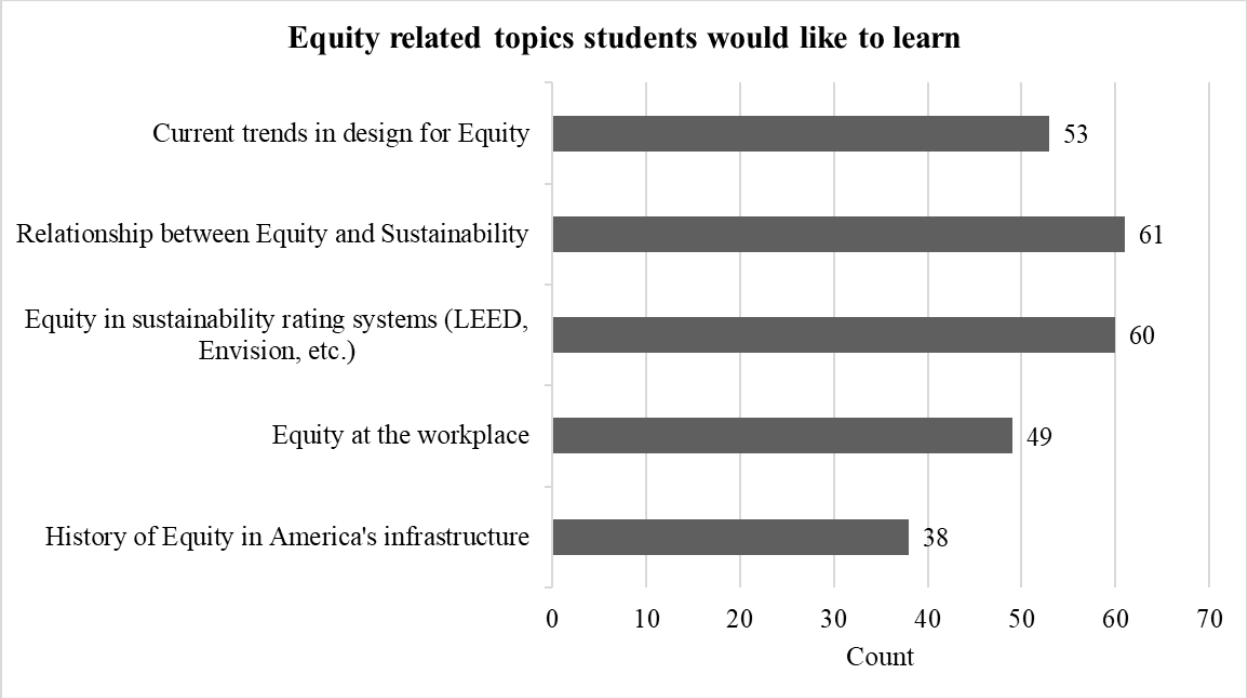
5. Findings:

5.1 Survey:

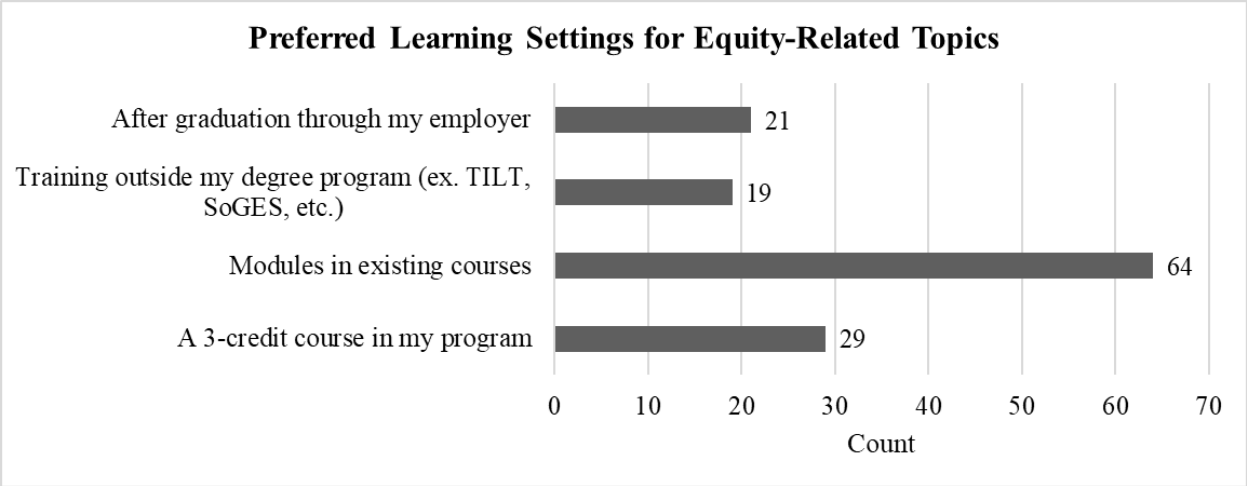
The survey aimed to explore perceptions of equity in transportation education and its relevance to professional practice. It focused on awareness, challenges, and preferences for integrating equity into the curriculum. A total of 146 respondents participated, representing a diverse range of academic levels. The majority of respondents were freshmen and seniors, comprising 39% and 27% of the total respondents, respectively. They came from various majors, including

Construction Management (47%), Civil Engineering (34%), Environmental Engineering (16%), and other disciplines (3%).

The survey revealed that students rated the importance of equity in their future careers at an average of 3.81 out of 5, indicating moderate to high awareness of its significance. In contrast, the industry's performance in implementing equity was perceived as only moderate, with an average rating of 3.27 out of 5. This highlights a gap between the perceived importance of equity and its practical integration within the industry.



Students showed the greatest interest in learning about the relationship between equity and sustainability (52%) and equity in sustainability rating systems (51%). Other topics of interest included equity in the workplace (42%) and the history of equity in America's infrastructure (32%). Many students preferred case studies (70%) and practitioner presentations (49%) as effective learning methods. This demonstrates that students are particularly keen on exploring the intersection of equity and sustainability. The significant interest in workplace equity, along with a desire to understand the historical context of inequities in infrastructure, indicates that students favor both practical and contextual approaches to equity education. Additionally, 66% of the total students preferred to learn the concepts about equity related topics through modules in existing course.



While 43% of the students expressed a potential interest in more equity-related content, the open-ended responses revealed mixed perspectives. Supportive comments highlighted the importance of equity in addressing systemic issues, with some students stating that it is essential for preparing future professionals to adopt inclusive practices. For example, one student noted, "*Equity is a topic that not everyone considers, and having an education on equity would be beneficial to the needs of others*." Another student suggested, *"Incorporating practical discussions of equity into courses would be useful."* In contrast, some students questioned the relevance or appropriateness of equity-related content. One student remarked, *"Equity is not particularly a topic I want to learn about in this course. I want to focus on technical skills."* Another asserted, *"I do not believe this should be taught in universities at all. Keep politics out of school and work."* These contrasting views highlight the challenge of framing equity in a way that resonates with students' career expectations while ensuring its inclusion in educational programs.

5.2 Interviews:

In our analysis of interviews with practitioners and educators, we identified three major themes related to our research questions. First, communication barriers in both practice and education hinder the integration of equity considerations into engineering education and professional environments. Secondly, the disconnect between the social and technical aspects of engineering education and practice presents a significant challenge to incorporating social equity, as technical training often takes precedence over social considerations. Lastly, the need for engineering students to acquire the skills, values, and knowledge necessary to address equity issues emphasizes the importance of bridging these gaps within educational programs. These themes reflect the main challenges identified from our analysis, which are explored in more detail below.

5.2.1 Communication barriers in education and practice

All the participants identified a communication gap in both education and practice regarding the understanding, integration, and delivery of the social equity considerations. They highlighted that this gap affects practical comprehension of social equity considerations. Equity is often misunderstood as addressing a lack of basic needs in professional practice. The concept of sufficiency is regarded as fair when the emphasis is on providing minimal services rather than striving for full equity. Interview 1A stated, *"we think of sufficiency as long as there's kind of barely enough, we call that fair and that's one approach to fairness. And so, we don't really try to make things very equal but try to provide some minimal service and benefits"* which highlights a lack of basic understanding of what equity is and how equity should be addressed in engineering.

Incorporating equity considerations into projects also often conflicts with clients' interests and goals. Many engineers find it challenging to persuade clients to prioritize fairness over financial gain. This conflict of interest poses a significant barrier to integrating social equity into engineering projects. Participants noted that offering multiple options to meet client requirements and allowing them flexibility in making final decisions may help encourage clients to include equity considerations.

In education, a significant barrier lies in how the concepts of social equity are communicated and taught to students. Engineering students, who are accustomed to learning technical theories and working with numerical data, often struggle with existing theoretical concepts of equity. Interview 1A noted, *"I had a graduate student with me, and some concepts they struggled with were too opaque and overly academic."* This indicates that the notion of social equity in engineering education can be unclear and highly theoretical. As a result, students may lose interest in these concepts, as they generally prefer to engage with data and analysis for their understanding.

Additionally, Equity has always been included as a consideration in engineering education and transportation settings, but it has never been treated as a primary objective. As mentioned by Interview 5A *"Until we begin talking about how equity and why it's a priority, it will always remain the last thing on the agenda, which is what we see today",* Students and practitioners should be taught to make equity the central focus of their projects and add social equity considerations in every societal and project stages. It should never be just for *"Checking the boxes"* for federal compliance.

One participant mentioned, *"everything has trade-offs, and nothing's going to be perfect*" meaning, tackling social issues is complex and there is never a perfect solution. However, we can always strive for improvements that address the most significant problems. Working toward social equity also means acknowledging that the standard for what is considered "fair" cannot be strictly defined; it must be adapted to fit each situation. Addressing social equity should be an ongoing process aimed at achieving better solutions in every effort.

5.2.2 Disconnect between social and technical in engineering education and practice

The prevailing views of engineering tend to prioritize certain aspects, like mathematical skills, while downplaying others, such as social context. Despite both being equally important to engineering practice, this has led to a significant disconnect between the social and technical elements of the field. This theme explains how this disconnect poses a major challenge in integrating social equity considerations into engineering.

Engineering is a technical field, and engineers are trained to think rationally due to their studies. As one participant noted, *"I was much like many engineers; I just wanted to get things done. Whatever it took, I wanted to ensure that these people had clean water and good sanitation."* Engineers tend to prioritize achieving results that are factual and measurable. In fact, for engineering students, *"quantitative numbers make sense"* because the engineering curriculum emphasizes this approach. However, social equity is not a straightforward, quantitative issue with a specific correct answer. It involves a complex process of incorporating everyone's needs, benefits, and burdens, which can only be improved with effort. While there are always better ways to consider social equity, when it comes to people and their needs, there is never just one correct solution.

Further, engineers rely on data and what it reveals. However, a significant challenge in this approach is that data is not always accurate. Even when it is accurate, there is often an underlying context that influences what the data represents. Engineers are trained to statistically analyze data but typically are not taught about the origins and circumstances that led to its collection. For instance, while engineers may study the demographics of a region, they often overlook the reasons behind the unequal distribution of income—such as why there are low-income households in the southern part of an interstate highway and high-income households in the northern part. There is a lack of focus on the social context behind this demographic disparity and the historical events that have influenced it, especially with regard to the placement of infrastructure like highways.

Additionally, engineering education often emphasizes completing projects, which can overshadow the social needs of the communities affected by these projects. As one interviewee (5A) noted, *"It's very easy to develop tunnel vision and forget that what you're designing and building has an impact beyond the immediate task at hand."* This focus results in a lack of attention to the effects on end-users. While engineering programs teach students how to create structurally sound designs, they often neglect to analyze the broader impact these projects have on society.

Also, the highly technical nature of engineering projects often leads to a lack of thorough engagement with equity issues; these concerns are typically addressed superficially to meet federal requirements. Even those who understand the fundamental concepts of equity frequently prioritize technical aspects of engineering, which can overshadow equity requirements. While some professionals recognize the importance of incorporating equity into their work, others, focusing primarily on creating technically sound structures, contribute to an environment not conducive to advocating social equity. This situation creates a dilemma in their careers, as engineers who prioritize technical excellence are often viewed as more capable. Interview 4A stated *"The World Bank has to give out loans to bring income and if you as an engineer created hurdles to approval of projects you just never got promoted"* highlighting the conflicts engineers face when choosing between their professional ambitions and personal values.

5.2.3 Need for Skills, Values and Knowledge for engineering students

Participants identified three key areas that should be taught to students to prepare them for tackling equity issues in practice: skills, values and knowledge. This theme highlights how these key areas help incorporate social equity in engineering.

Skills:

Participants emphasized the importance of soft skills—such as communication, persuasion, and empathy—as essential for students. Equity issues are sensitive and often require extensive interactions with end users. Therefore, the ability to communicate effectively and understand the perspectives of these users is vital for students to transition into practice. It is also crucial for students to remain open to listening to others' opinions and experiences without holding preconceived notions. Developing these skills can enhance their understanding and application of social equity concepts. One participant reflected on their experiences, stating, *"I need to reframe the way I approach engineering and consider the social and political factors that contribute to the technical problems I observe."* This highlights that equity is influenced not only by social factors but also by significant political and historical decisions. Consequently, equity issues in

engineering should be addressed through a thorough analysis of historical, social, and political contexts. Therefore, students should enhance their critical analysis skills to comprehend the underlying reasons behind existing inequities.

Interview 3A suggests that students should learn the skill of questioning existing infrastructure. They state, "*An example of where equity gets integrated is asking whether we still need those facilities and if they remain useful in the same way they were at the time of their initial construction. What is the condition of the asset? What materials were used? We often overlook the social contexts that will be impacted by these decisions."* Developing this skill of analyzing existing infrastructure enables students to critically assess their future projects and determine whether they meet equity requirements at every level.

Practical engagement, such as consulting with community members during project planning, empowers students to consider the social implications and ethical responsibilities that are integral to engineering work. These experiences cultivate a mindset that prioritizes equity as part of professional practice, preparing future engineers to focus on community well-being and inclusiveness in their careers.

Values:

Over 80% of the participants referenced lived experiences that motivated them to work in the field of social equity. These experiences were not limited to their own life stories; they also included narratives encountered while engaging with diverse communities. As Interview 3-A stated, *"Thinking about the ways to provide real-world, first-hand experience as opposed to just theoretical or academic approaches can instill curiosity in students, encouraging them to explore equity considerations in their studies and work."* This is because the relatability factor increases when real-life experiences are incorporated.

Students should be taught to incorporate moral values into their work and to empathize with others. The ability to adapt allows students to communicate in different styles, catering to various perspectives. This skill ultimately enables them to consider diverse requirements in their projects. Interview 4A mentioned "*in the case of like drinking water, if your child's going to drink the water, you're going do a lot more homework to make sure that's good than if it's someone else's child in another country.",* highlighting that having a relatability factor can motivate students to look beyond the direct impact of the project.

Students can best understand social inequities through direct involvement with the community and its stakeholders. This engagement helps them identify basic needs and fosters empathy for existing disparities. Direct interaction allows them to develop a personal connection to both the people and the projects, creating a sense of ownership and belonging. For example, Interview 5A illustrates this point: *"that road or that bridge, how does that potentially impact their community if they were to take that road and bridge and put it in your community, what could be the burden and what is the benefit, making them see it through their lens".*

Students should also be made aware of the impact of their decisions. Engineering students design projects that directly serve the public and have broader implications beyond the primary purpose of the project. Interview 2A stated "*People built highways that cut through distinctly black and brown communities, displacing so many communities. And today we're seeing the ramifications of that"*, highlighting the importance of analyzing the decisions we take. There will always be indirect end users whose lives are affected by these choices. Students should be aware of not only the services they provide but also the potential burdens their projects may impose on end users. By helping students understand the direct and indirect consequences of their decisions, we can encourage them to consider equity in their projects. Additionally, students should be made aware of any unconscious biases they may hold; discussing these biases can help them gain a better understanding of various perspectives.

Knowledge:

There is often a discrepancy between how society identifies social inequity and where the actual issues lie. Therefore, students should be educated about these differences and be able to identify the inequities that persist in society. Students should also have knowledge of existing resources and frameworks such as Justice 40 initiatives, Title VI of civil rights acts, as working with foundational material often yields a better product than creating an entirely new framework. Furthermore, federal law imposes significant requirements on planners and engineers to address equity at every stage of a project. Students who understand these frameworks can play a more impactful role in integrating social equity considerations. However, since existing infrastructures were developed based on policies that have since undergone substantial reforms, resulting in a different impact in today's context, students should be taught to reassess the existing infrastructure, its usages, and the effects it has on its end users.

Statistical analysis of demographics has traditionally been an engineering approach. As mentioned by one of the participants "*numbers can mean anything until you put context into them"*, allowing students to explore the contextual reasoning behind the disproportionate distribution of demographics can provide them with a foundational understanding of the root

causes. Interview 5A further emphasizes *"Data is very important, but at the same time this push for data is actually very frightening to me too, because so much can be shifted and changed and worded wrong, when you have and focus on the data so much".* Understanding the context and the social perspectives involved requires a qualitative approach. Therefore, engineering education should balance both qualitative and quantitative methods. This balance helps students relate the results of their statistical analysis to the reasons behind those results.

6. Discussion:

The themes that emerged from the interviews illuminated the challenges and methods associated with integrating social equity into engineering education. They also emphasize the need to bridge the gap between technical expertise and social responsibility, particularly in civil engineering, to prepare engineers for design solutions that address the existing inequities and meet diverse community needs.

Engineers often face challenges due to the lack of a clear and consistent definition of equity. Unlike their usual work, where they seek single correct answers, equity cannot be strictly defined and addressing it should be an ongoing process. This confusion has created a communication gap regarding equity concepts among various stakeholders. Educators also struggle to engage students' curiosity about equity because the current approach to teaching tends to be highly theoretical. Meanwhile, engineers find it difficult to justify integrating equity into their projects for clients, as they often fail to demonstrate its importance in comparison to financial gain. To bridge this communication gap, equity in engineering should be specifically defined and tailored to meet the unique needs of each project. Additionally, it should be integrated into the entire project process and considered at the societal level, rather than treated as an afterthought. In engineering education, collaborative efforts among educators, practitioners, and end users can facilitate discussions that help students identify the unique needs each project presents. Rather than focusing solely on theoretical concepts, educators should emphasize engaging students with the community and direct end users. Experiential learning opportunities—such as field visits, community-based projects, and interactive workshops—allow students to see firsthand how engineering decisions impact various groups within a community, thereby fostering their curiosity. By incorporating community perspectives into the classroom, students will learn to approach projects with a focus on equity and inclusiveness.

The highly technical nature of engineering education has led to a social disconnect within the field. However, recognizing the need for social context in engineering education and projects is essential, as every engineering project has implications for society and its end users. Therefore, it is necessary to reframe the engineering discipline as socio-technical, which would help dissolve existing boundaries. According to Niles et al. [18], expanding the practice of engineering beyond

mere technical problem-solving and integrating multidisciplinary aspects can illuminate the social contexts and implications of the field by redefining the boundaries of engineering knowledge. Additionally, case study-based learning can challenge the prevailing techno-centric ideology in engineering. By incorporating historical, political, and social analysis, we can provide the necessary context, while empirical data analysis lends factual support. Furthermore, sharing real-world experiences or narratives from individuals who have faced issues of inequity can effectively challenge the technical-focused mindset in engineering. This approach can help develop a greater empathy for end users and foster a sense of care within the discipline. Shuman et al. [19] addresses the issue of socio-technical disconnect through the difficulties educators face in rendering the concepts of social justice visible to students. Educators may find it challenging to address the normalcy and superiority that are inherent in unconscious or implicit biases, as these subjects have not often been emphasized in engineering education [19].
Therefore, creating educational approaches which can challenge the traditional technical nature of engineering education can help educators emphasize the social aspects of the field more effectively.

The study underscores the importance of equipping students with critical skills, values and knowledge. This includes skills such as communication, persuasion, empathy, ethical decision-making, critical analysis, perspective thinking, questioning, practical engagement, and knowledge of infrastructural analysis, historical, political and social frameworks, existing resources and frameworks. These skills, values and knowledge, along with a deeper understanding of equity principles prepare students to navigate the complexities of real-world engineering challenges. Embedding these elements into engineering education is vital for fostering socially responsible engineers and adopting interdisciplinary approaches to teach these skills, values, and facts can have a profound impact.

7. Conclusion and Future work

This study examined perceptions of equity, highlighting key challenges and opportunities for incorporating equity into engineering education. The findings indicate that students have a moderate to high awareness of the importance of equity in professional practice; however, they perceive a disconnect between this awareness and the current performance of the industry in implementing equity measures. Students expressed differing opinions on the relevance of equity in education. Practitioners and educators identified various technical, social, communication, and educational barriers to integrating social equity considerations and advocated for its inclusion. This suggests the need for thoughtfully designed content in engineering education that aligns with students' career aspirations while addressing systemic inequities. Integrating social equity into transportation and engineering education has implications that extend beyond the academic sphere. By confronting these challenges and connecting technical skills with social responsibility, as well as addressing gaps in equity within both practice and education, engineers

can be better equipped to develop sustainable solutions that meet the diverse needs of communities and help reduce systemic inequalities. It is essential to tackle these challenges in order to promote a more inclusive and equitable engineering profession.

This study highlights important challenges and opportunities, but further research is needed to explore how these reform approaches can be implemented in the engineering curriculum. It is crucial to investigate the long-term impact of equity-focused educational reforms and to develop more effective methods for measuring their success. Future efforts should prioritize the creation of equity-focused modules that can be integrated into the engineering curriculum. These modules might include interdisciplinary case studies, sustainability-focused projects, and workshops led by practitioners to provide students with practical, contextual learning experiences. Additionally, pilot programs could be established to evaluate the effectiveness of these modules, collecting feedback from both students and educators to refine and expand their application. Collaborating with industry professionals can also help create frameworks that ensure equity education remains relevant to current practices and aligns with professional standards. These initiatives will contribute to the development of a new generation of socially responsible engineers who are equipped to incorporate social equity considerations into transportation and beyond.

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Appendix:

Interview Questions:

Introduction

As part of a study aiming to update the curricula for civil engineers, environmental engineers, and construction managers, this interview asks you, as an academic, about social equity in the context of the built environment. We want to know: How is equity currently part of your work, especially in terms of educating students? And how can it be part of education for future practitioners?

Before we start, we would like to share how the research team looks at equity from two angles: equity for the end-users and equity for the workforce.

- Equity for end-users refers to the fair distribution of benefits and costs of the built environment (i.e., buildings, dams, energy, roads, broadband, or water) for all people who may use or be affected by the infrastructure.
- Equity for the workforce refers to employees (labor, managers, engineers, etc.) receiving fair treatment and equal opportunities based on their individual needs.

Questions

1. Given this understanding of social equity, how did you learn/continue to learn about equity? What is your experience with equity or some examples of equity-related work?
2. How/what have you learned about the equity work that is going on in professional practice?
3. What equity-related knowledge should students gain in college? (LCA, measures, certifications, how to talk to policymakers/owners/ investors…)
4. How would you suggest these concepts and knowledge be taught to students? What are the preferred methods and tools to do so?

Survey Questionnaire:

1. What year are you in?
    - Freshman
    - Sophomore
    - Junior
    - Senior
    - Graduate

- Other. Please specify.

2. What is your major?
    - Construction Management (CM)
    - Civil Engineering (CE)
    - Environmental Engineering (EE)
    - Other. Please Specify.
3. To which age category do you belong?
    - 18 years old or younger
    - 19 to 21 years old
    - 22 to 24 years old
    - 25 years old or older

This picture is an example of **equity in the built environment.**
Providing the same bike to all individuals without consideration of their needs and capabilities is equality, which is different from equity.
An **equitable approach would be to provide the benefit** (bike) **based on the needs** of the end-users (people with disabilities, people with varying heights and physical traits, etc.).

(*Robert Wood Johnson Foundation,* 2017)

Equity for end-users refers to the fair distribution of **benefits and costs** of the built environment (i.e., buildings, dams, energy, roads, broadband, or water) for **all people** who may use or be affected by the infrastructure.

4. How would you describe the possible relationship between your practice in the future (engineering, management, planning, etc.) and equity in the built environment? *(Rate on a scale from 0-5)*

5. In your opinion, how is the industry you plan to work in doing in terms of incorporating equity for end-users? *(Rate on a scale from 0-5)*
6. In your future career, how important will equity for end-users be to the professional decisions you make? *(Rate on a scale from 0-5)*

Equity for the workforce refers to the fair treatment of the workforce **(labor, managers, engineers, etc.), i.e.,** no discrimination **based on age, race, income level, gender, etc.**

7. In your opinion, how is the industry you plan to work in doing in terms of incorporating equity for the workforce?
8. In your future career, how important will equity for the workforce be to the professional decisions you make?
9. The following topics relate to equity education. Please select the topics you would like to learn about whether in class or elsewhere. *(Select all that apply)*
    - History of Equity in America's infrastructure
    - Equity at the workplace
    - Equity in sustainability rating systems (LEED, Envision, etc.)
    - Relationship between Equity and Sustainability
    - Current trends in design for Equity
    - Other. Please specify.
10. Would you like to see more content/sessions related to equity while you're a student at CSU and/or in your professional career?
    - Yes, for sure!
    - Yes, maybe.
    - Not sure.
    - No.
11. When and where would you prefer to learn about these equity-related topics?
    - A 3-credit course in my program
    - Modules in existing courses
    - Training outside my degree program (ex. TILT, SoGES, etc.)
    - After graduation through my employer
    - Other. Please specify.
12. How would you prefer to learn about these equity-related topics? (Select all that apply)
    - Class discussion
    - Case studies
    - Presentations by practitioners
    - Other. Please specify.
13. Please share any questions/thoughts/comments you might have on this topic.