Teaching Social Justice in Infrastructure: A Community of Practice Framework for the use of Case Studies

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Abstract

The Center for Infrastructure Transformation and Education (CIT-E) was created in 2013 as a community of practice (CoP) for those interested in the scholarship of infrastructure education and has developed a model introductory infrastructure course with over 40 lessons available to any instructor to use or modify. In the summer of 2023 CIT-E held a workshop "Teaching Students about Equitable Infrastructure". As a result of that workshop, one of the ongoing efforts has been the development of a module focused on the broad topic of Repairing Inequities in Infrastructure.

This paper aims to outline the broad objectives of this module, the procedures used by the CoP, and the desired outcome. It will present a framework that is currently being created to assist instructors in developing their own lessons related to past or present infrastructure inequities that could be used in any course that touches on infrastructure. The objective of this framework is to provide an easy-to-use model to facilitate the development of lessons related to infrastructure topics that highlight Justice, Equity, Diversity, and Inclusion (JEDI) aspects. The framework will provide a solid foundation for faculty to take a case study or historical example, create or select learning objectives and design exercises to help students identify inequities created by infrastructure, understand the historical context of that infrastructure, and plan for solutions that address the remediation of infrastructure inequities. As the framework is being developed, the authors are testing its effectiveness and adaptability by creating lessons based on case studies. The framework as well as the lessons created will be available through the CIT-E Canvas page to all interested instructors.

Introduction

The Center for Infrastructure Transformation and Education (CIT-E, pronounced "city") is a community of practice (CoP) for those interested in supporting and improving the scholarship of infrastructure education. It was created in 2013, through a National Science Foundation (NSF) grant that enabled faculty from different universities to attend six workshops where they started to co-create material for an introductory infrastructure course. Since then, yearly workshops have been offered to introduce potential members to the community of practice, share materials developed over the years, assist new members in adapting existing material for their courses, network, and continue to develop new lessons. At this time, the community has developed 44 peer-reviewed lessons that any faculty member can access and modify to fit their teaching needs. A survey was conducted in 2020 to determine CIT-E's impact, as well as community members' interests [1]. Due to the large number of members interested in addressing the social impacts of infrastructure, including the intersection of infrastructure and inequity, workshops covering these topics were conducted in the past three summers. In the summer of 2023, CIT-E held a workshop titled "Teaching Students about Equitable Infrastructure" where participants were asked to brainstorm potential lessons or module topics after short presentations from CIT-E members who had integrated course material or activities related to equitable infrastructure in their courses. Voting on the most popular topics followed and groups were formed based on each participant's

interest. The authors of this paper were part of the group focused on the broad topic of Repairing Inequities in Infrastructure. They were motivated by the idea that social justice requires an attempt at an equitable distribution of rights, opportunities, and resources to maximize the benefits and mitigate the harms inherent in all infrastructure and that engineers need to be a part of this process [2]. A true social justice mindset must reframe the focus of infrastructure engineering on the repairing of past harms, and the elimination of future harms in new infrastructure improvements [3]. The objective is to learn from the past to prepare for the future. To address the need to better frame problems and develop lessons related to equitable infrastructure, the team has been meeting virtually every two weeks since the workshop to develop a framework that would facilitate the adaptation of case studies related to infrastructure inequities to civil and environmental engineering courses. This work aligns with the Engineering Accreditation Commission (EAC) of ABET's Criterion 3, Student Outcomes. There seems to be a desire to encourage programs to relate technical knowledge and societal needs like the ones related to equitable infrastructure. Specifically, Student Outcome 2 requires that students have "an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors"; and Student Outcome 4 "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts" [4].

Addressing JEDI principles and equitable infrastructure in civil engineering education

After reviewing the literature on how Justice, Equity, Diversity, and Inclusion (JEDI) is incorporated in civil engineering curricula, Carroll et al. [5] noticed that "while there is some discussion of the importance of incorporating DEIJ in the curriculum," there is also "a lack of professors' processes regarding implementation." This sentiment was echoed by Pellissier et al. [6] who stated that "while the value of incorporating EDI concepts into engineering education is widely acknowledged, there is no consensus on the best method of implementation." A literature search confirmed these claims and revealed that JEDI topics were usually addressed in: (1) a dedicated course [7] [8], (2) readings and/or activities in existing civil and environmental engineering courses [7] [9] [10], (3) seminars and/or workshops [6]. Although the incorporation of a course dedicated to JEDI in civil engineering taught by a faculty proficient in this field could be an ideal scenario, it may not be feasible at several institutions due to their already full civil engineering curricula, limits on the number of units/credits needed to graduate, and/or a lack of instructors who feel qualified to fulfill this requirement. The lack of preparedness to adeptly navigate discussions within these areas is also a challenge for faculty interested in introducing JEDI in their individual courses [11] [6]. To facilitate this process, the framework described in this paper will include examples that will help faculty place their case studies in a cultural context and historical timeline. This framework will also provide resources and suggest background readings, videos, and other materials that could be used in the classroom or to better prepare the instructors to address these topics in their courses. Moreover, the lessons created using the framework will highlight that to effectively repair unjust elements of the built environment and related systems, one must acknowledge that the conscious and unconscious biases and values held by engineers have impacted what infrastructure was built and how it was built [3].

Methodology

This work builds on the concept of "creating significant learning experiences" from Fink's Taxonomy of Significant Learning [12] and utilizes Bloom's Taxonomy of Cognitive Learning [13] [14] to develop learning objectives. According to Fink [12], these experiences can influence students' lives in different dimensions, from individual changes, to how they interact with peers, how they impact society at large by engaging in civic processes and, ultimately, set up the stage for a lifelong professional engagement and learning on important societal matters. For significant learning experiences to take place, Fink [12] defines a taxonomy through six elements which work in an integrated fashion in student knowledge development. The authors adopted this learning taxonomy to form the foundation of the work presented in this paper:

- Foundational knowledge – includes the building blocks of the disciplines being studied. In the framework presented, this is addressed by using assignments that allow students to demonstrate a basic understanding of societal rights in terms of what is available in the built environment, to identify inequities in infrastructure, and how they are propagated.

- Application – students use the foundational knowledge acquired in the initial lessons of a course, or over the curriculum, to start designing solutions to address existing problems in infrastructure. As students work on assignments, they apply critical and practical thinking skills to address multi-dimensional problems. During the application process, there is no singular strategy to address social inequity in engineering, hence the need for multiple approaches [15]. Showcasing case studies in the classroom may serve as a source of inspiration and ideas, and as a reminder that engineers can actively contribute to social justice, as well as social injustice. Martina and Beseb found that "bringing real-world problems into the classroom can serve as a vehicle to engage students about the ever-present importance of social justice and potentially change mindsets." [16].

- Integration – happens when students are informed, when they engage in interdisciplinary discussions, explain how multiple factors have contributed to infrastructure inequities and how they can be part of the solution. This also emphasizes the importance of relying on multiple disciplines in different fields of knowledge to address JEDI issues. Additionally, the framework proposed includes, in its structure and suggested activities, multiple opportunities for students to evolve from foundational understanding to thinking in multi-disciplinary ways and being creative in the design of solutions. Collaborative efforts and increased visibility of these narratives among the engineering students, and the community at large, will amplify the potential for meaningful change towards JEDI in engineering practices. Particularly, students will learn about the historical temporal dimension of engineering and social justice through a series of case studies, recognizing that the impacts of engineering span multiple generations, irrespective of whether these effects are positive or negative. This realization will empower students with a sense of continuity and a need for collective efforts, it will enable them to break the barriers of individual accountability, micro-ethics, and direct causality commonly established in engineering practice [17]. This mindset shift acknowledges the need for continued social justice work beyond individual lifetimes, fostering a sense of interconnectedness and shared responsibility within a larger community [15].

- Human dimension – addresses personal stories and background of students, their peers, and the society they are part of. Topics addressed by the proposed framework allow students to evaluate how they are part of society's fabric, recognize civic duties, and relate to the built environment around them. This is a central element in the proposed framework as students develop an appreciation for what they are learning, how that applies to their professional context, the ethics associated with the built environment, and how their own values align to address societal problems related to infrastructure. Particularly, students will be encouraged to find their own human dimension in these JEDI issues and to discover and kindle their personal motivation, so that once the lesson or the course is over, they will continue to strive for changes in their engineering practice.

- Caring – is closely related to the human dimension as students might become more caring and interested in solving infrastructure inequity problems when they can not only understand but also relate to the problems. Students become more engaged in learning about topics they care about.

  Classroom structured discussions on case studies serve as a powerful tool to foster the development of critical thinking skills among students. By delving into real-world scenarios, students are prompted to brainstorm and engage in those reflections needed to evaluate complex situations, which often involve socio-economic and political considerations. Case studies have been shown to be an effective way to do that, and an effective case study allows students to go beyond the simple facts of the case by looking at laws past and present, historical context, and current practice and lead them to make informed decisions [16]. This process not only enhances their analytical abilities but also encourages them to explore new dimensions of the engineering practice, facilitating that much needed shift to a more equitable and socio-centered engineering practice. This broader perspective encourages students to consider the social, ethical, and environmental dimensions of their future roles as engineers, fostering a sense of responsibility and promoting socially conscious practices within the field.

- Learning how to learn – the framework and the case studies analyzed will provide students with the proper foundational knowledge necessary to recognize and avoid inequities in future infrastructure projects. They will also encourage students to be intentional and continue to seek additional knowledge and connections to solve problems they can relate to and care about.

Results

As the authors engaged in discussions about how to develop the framework presented in this paper, they identified foundational building blocks to define equitable infrastructure based on JEDI principles, as well as instances where these principles had been historically ignored. Gradually, the authors iterated between the foundational concepts identified and ways to potentially incorporate them in a classroom setting. The use of case studies, as discussed in the methodology section, became an important strategy to help students progress from identifying and understanding inequities in infrastructure to being able to design solutions to address

previous problems. Thus moving from lower levels in Bloom's Taxonomy of learning outcomes (remember, understand) through higher level outcomes involving more advanced levels of critical thinking and problem solving (evaluate, create).

This section presents the work developed by the authors, which includes an encompassing framework for teaching JEDI principles applied to the development of equitable infrastructure to civil engineering students within a classroom setting. The framework presents systematic guidance applicable to instructors at any level of expertise in this domain. The framework is structured for implementation in diverse teaching environments within the civil and environmental engineering curriculum, and its adaptability extends to various course requirements, aiming to offer comprehensive information, including suggested pre-class, in-class, and post-class activities. The framework is also tailored to accommodate different teaching levels, from lower division to upper division courses, as it unfolds across six distinct steps, allowing instructors the flexibility to integrate specific components or the entire framework seamlessly into their teaching agenda. The authors have created a schematic that reflects the steps for implementing the framework (Figure 1).

Step 1, the first step is to select a topic or an issue, aligning with either historical or contemporary contexts based on the instructional requirements. Opting for historical subjects allows an in-depth analysis of their impact over time, while contemporary issues underscore the persistent challenge of inequity. Furthermore, the suggestion is to explore local issues, as they tend to resonate more profoundly with students, fostering a heightened sense of relatability. At this stage, instructors are strongly encouraged to discuss the Code of Ethics by the American Society of Civil Engineers [18] and the principles that govern the civil engineering profession: "create safe, resilient, and sustainable infrastructure; treat all persons with respect, dignity, and fairness in a manner that fosters equitable participation without regard to personal identity; consider the current and anticipated needs of society; and utilize their knowledge and skills to enhance the quality of life for humanity." The ASCE Code of Ethics indicates society as its main stakeholder, followed by the natural and built environment, the profession, clients and employers, and peers. This code specifically calls engineers' attention to "a. first and foremost, protect the health, safety, and welfare of the public"; "b. enhance the quality of life for humanity;" and "g. acknowledge the diverse historical, social, and cultural needs of the community, and incorporate these considerations in their work;" among other responsibilities.

In step 2, faculty members are encouraged to choose a compelling case study that effectively illustrates the selected topic or issue. These case studies can span historical or contemporary contexts, with a preference for local instances to enhance student engagement. Complementing the framework, the authors have started to curate a repository of case studies, conveniently accessible to instructors via the CIT-E Canvas page. Two such cases are discussed in a companion paper [19], illustrating the framework's application.

Figure 1 - Framework schematic

In step 3, the emphasis lies in determining the extent of requisite background information. In this context, the authors propose a structured approach featuring four elements tailored to teaching social inequity within the civil and environmental engineering domain. Instructors possess the flexibility to integrate all four elements or select specific ones that align with their individual teaching objectives and curriculum. Element one centers on defining and exploring inequity, with the aim of enabling students to articulate the concept of infrastructure inequities. Element two delves into background, context, and historical perspectives, fostering student awareness regarding how infrastructure placement influences residents' access to work, food, housing, and education. Element three shifts the focus to the impact, prompting students to identify stakeholders and comprehend the repercussions they are experiencing. Finally, element four centers on remedy, empowering students to design plans for the deconstruction or repairing of outdated infrastructure and the implementation of new infrastructure to eradicate inequities.

Step 4 aims to determine the instructional level at which the chosen topic or issue will be addressed. Notably, this framework is structured to cater to a broad spectrum of academic settings, ranging from freshman to graduate-level classes. Moreover, in cases where multiple elements are under consideration, instructors have the flexibility to opt for distinct Bloom's Taxonomy levels for each element, enhancing the adaptability and customization of the instructional approach.

Step 5, consists of the selection of objectives for the lessons. The framework provides examples of multiple objectives that are listed in each category to facilitate the process.

Transitioning to step 6, the focus shifts to selecting pre-class, in-class, and post class activities. The framework also includes a rich array of example activities and discussions tailored to each of the four framework elements, at various levels of Bloom's Taxonomy.

Conclusions

Civil engineering projects have a significant impact on society, including technical, environmental, and social impacts. However, infrastructure social justice has been overlooked, largely due to historical neglect and lack of comprehensive social impact education for civil engineers. With this in mind, the authors' objective was to develop an easy-to-implement framework that: 1) facilitates the introduction of course lessons in infrastructure inequities through the use of case studies, 2) promotes discussions, and 3) engages the interest of future professionals in repairing past inequities and preventing future ones. The easy-to-implement framework steps provide a solid foundation for instructors to select a case study that illustrates a chosen topic, prepare background information, determine the learning objective levels for a particular lesson based on Bloom's Taxonomy, and select or create activities to be conducted inside and outside the classroom.

The choice to use case studies supports the creation of significant learning experiences, as proposed by Fink [12], and allows students to see social justice applied to and interacting with existing infrastructure surrounding their daily lives. This creates a symbiotic relationship between the work students develop as part of their coursework and what they encounter in their

daily lives, promoting a culture of caring for social issues and civic duty as part of their engineering profession.

The authors envision that this framework will help students gain foundational knowledge to recognize past inequities and be challenged to design solutions to promote JEDI principles in the built environment. It will also help faculty members new to JEDI instruction gain the knowledge and confidence they need to tackle these subjects in their classes, in addition to encouraging and facilitating the incorporation of JEDI principles in multiple classes, since the framework is adaptable to a variety of levels, topics, and courses. The authors hope that this work will promote the teaching of social justice across the civil engineering curriculum, enabling students to embrace the incorporation of JEDI principles into their technical knowledge and, ultimately, into their designs, first as students, and later as professionals. Finally, the applicability of the framework may even extend beyond civil engineering higher education. By tailoring the level based on Bloom's Taxonomy, it can also be implemented in other contexts, such as secondary and high schools, particularly for addressing specific topics related to infrastructure social justice.

Future Work

The authors will continue to refine the framework with additional resources and activities. They will also use it to develop lessons which will be incorporated into their existing courses in different universities. Once peer-reviewed, these lessons will be placed in a repository on the CIT-E Canvas page where they will be available to all interested instructors. The authors plan to report about the results in future publications.

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