Fostering Infrastructure Equity through Leveraging Envision Rating System among Civil Engineering and Construction Students

Miss Rubaya Rahat, Florida International University

Rubaya Rahat grew up in Bangladesh, where she pursued her Bachelor of Science in Civil Engineering at the Bangladesh University of Engineering and Technology (BUET). After graduating she worked for two years in a construction management company in Dhaka, Bangladesh. She was involved in various residential and infrastructure projects. Rubaya now is a Ph.D. student at Department of Civil and Environmental Engineering and Teaching/Research Assistant at Moss School of Construction, Sustainability and Infrastructure, Florida International University. Her research interest includes Sustainable and resilient infrastructure, Engineering Education, and Sustainable transportation system.

Mr. Mohamed Elzomor, P.E., Florida International University

Dr. Mohamed ElZomor is an Assistant Professor at Florida International University (FIU), College of Engineering and Computing and teaches at the Moss School of Construction, Infrastructure and Sustainability. Dr. ElZomor completed his doctorate at Arizona

Fostering infrastructure equity through leveraging Envision rating system among civil engineering and construction students

Abstract

The sustainability concept relies on the three pillars of the triple bottom line which include social, economic, and environmental sustainability. Although economic and environmental sustainability is widely implemented, social sustainability or social equity is yet to gain traction. As globalization increases, engineering professionals and stakeholders must prioritize and incorporate social equity for the construction of sustainable developments, particularly infrastructure systems as they are the critical component of a functioning community. However, civil engineering and construction (CEC) education hardly focuses on disseminating knowledge about social equity, particularly equity in infrastructure systems thus hindering the path of creating equitable and sustainable future developments. Therefore, it is critical to introduce and educate future engineering professionals about infrastructure inequity issues as well as train them to ensure equity for both new and existing infrastructure systems through effective techniques. This research investigates the existing awareness of infrastructure inequity issues among CEC students and proposes effective solutions to improve such knowledge and awareness as well as equip them with techniques to address the issue by leveraging Envision sustainability rating system. To achieve this objective, the study implemented a training/workshop in a cross-listed sustainability course about various critical concepts of infrastructure inequity as well as how to address this issue through utilizing the Envision rating system. At first, the study conducted a pre-survey to record pre-established knowledge of the participants about social inequity and the importance of equitable infrastructure systems. Then, during the training, the students were introduced to important topics that include social inequity, gentrification, infrastructure inequity, equitable access to infrastructure, sustainable infrastructure rating system, and various credits of Envision rating system that support equitable infrastructure. The study conducted a post-survey of the participants following the training. The pre and post-survey responses were analyzed using the McNemar test. The results indicated that guided training helped the students to understand infrastructure inequity concerns and can potentially nurture their knowledge to address and mitigate such issues through implementing the Envision rating system. Furthermore, the boxplots demonstrating the self-assessment of the students highlighted that the training was effective to improve awareness among the students regarding the necessity of equitable infrastructure systems. The findings of the study would be valuable for increasing awareness of infrastructure inequity and facilitating the future construction workforce with the required knowledge to ensure an equitable infrastructure system.

Background

Infrastructure projects are crucial components of the built environment since they support personal safety and public health, have an impact on socioeconomic development, provide access to clean water and waste removal, and most importantly, enable building and industrial projects to connect to all major utilities. With all 50 Democrats and 19 Republicans voting in favor, the

U.S. Senate enacted a $1.2 trillion bipartisan infrastructure bill on August 10 by a vote of 69 to 30 [1]. The Act renews funding for ongoing initiatives and allows $550 billion in new investments in infrastructure projects around the United States. In addition to repairing water systems, reconstructing the electric grid, improving broadband and internet access, and creating a network of electric vehicle chargers thus encouraging sustainable transportation modes, it also involves funding for more conventional infrastructures including roads, bridges, airports, ports, rail, and transportation. Additionally, it includes $1 billion to "reconnect communities," primarily black and low-income neighborhoods that were divided by previously built highways and infrastructure developments, and $21 billion for the environmental cleanup of hazardous waste sites [2]. According to Biden's plan, $20 billion would be allocated to fund neighborhood-driven initiatives to move motorways and regenerate urban cores, along with more equitable plans for multimodal infrastructure or sustainable green space [3]. Such equitable and sustainable project plans will require the team members to be equipped with proper knowledge and skills about infrastructure sustainability and equity to support implementing these initiatives successfully. Therefore, it is essential to introduce the future engineering workforce and improve their competencies in developing sustainable and equitable infrastructure systems by addressing the economic, social, and environmental or triple bottom line (TBL) impacts.

The Triple Bottom Line (TBL) is a set of economic, social, and environmental factors that aim to improve the performance of the built environment including infrastructure systems through sustainable construction [4], [5]. Considering that the majority of natural resources are limited, and rapid community growth has implications on the TBL, the development of infrastructures must not only be robust but also sustainable [6], [7]. However, sustainability is frequently referred to as environmental sustainability, overlooking its other two essential pillars: social and economic. Thus, infrastructure systems frequently lack social justice which leads to an unbalanced influence on different populations through different mechanisms, such as eviction, exposure to environmental danger, and access to necessary services. Even while engineers and policymakers base their decisions on technical and engineering factors, social and racial disparities are exacerbated by stakeholders' choices, which reflect current economic and political frameworks [8]. Therefore, the project team members must be sufficiently competent to address these challenges and construct infrastructures that are sustainable, resilient, and equitable. To address the infrastructure inequity concerns, this study recommends that civil engineering and construction (CEC) students be taught about them and given proper training on how to do so by adopting the Envision infrastructure sustainability rating system. Thus, this study advocates for social sustainability and affirms the necessity of prioritizing and teaching about it to CEC students in order to provide them with the fundamental knowledge they need to help create equitable and sustainable infrastructure systems.

The existing engineering and construction sector is seeking a more dynamic workforce with knowledge beyond the usual technical principles. Moreover, studies have shown that a stronger foundation for sustainability principles is urgently needed within the future engineering workforce [9], [10]. With similar goals, *The Vision for Civil Engineering in 2025*, a publication of ASCE, discussed the significance of sustainability and the necessity to include it in schools

and colleges [11]. However, the social aspect of sustainability, such as concerns with infrastructure equity, is often left out of sustainability education initiatives. This may be because incorporating social sustainability into an infrastructure project might bring many additional challenges. Although previous literature had studied infrastructure inequity and relevant topics which were in limited scope. For instance, Bolding et al. (2021) assessed the perceptions of civil engineering undergraduate students about infrastructure inequities and their support to promote systemic changes to address this issue [12]. Oulton et al. (2021) investigated the existing knowledge of civil engineering students about social and environmental justice and assessed the efficacy of a curriculum enhancement to improve the students' knowledge about these topics [13]. Likewise, Armanios et al. (2021) integrated the diversity, equity, and inclusion principles within civil and environmental engineering curricula by incorporating discussions of how civil engineering projects are linked to inequitable pollution concentrations, lack of access, and displacement of low-income communities thus improve understanding and experience of these topics [14]. Other studies focused on teaching about adopting social sustainability during the planning and design phases of construction projects [15] as well as highlighted the primary challenges associated with the incorporation of social sustainability into engineering education [16]. However, literature has yet to investigate the existing knowledge about infrastructure inequities of CEC students and train them to improve their knowledge about such issues and how to address these issues as engineering professionals through leveraging Envision sustainability rating system. As the students make up the country's future workforce, the resolution process should begin with them in order to deliver equitable, sustainable, and successful infrastructures.

To this end, the Envision rating system is briefly described in the following section.

The Envision™ Rating System

Sustainability rating systems emerged as critical guidelines to implement sustainability principles by addressing the TBL impacts of construction projects. Among others, Envision rating system is a widely used infrastructure sustainability rating system that assesses all types and sizes of infrastructure projects [17]. The Institute for Sustainable Infrastructure (ISI) and the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design collaborated to create this rating system. This rating system includes 64 sustainability and resilience indicators, or "credits," inside a specific framework made up of five categories: Quality of Life (QL), Leadership (LD), Resource Allocation (RA), Natural World (NW), and Climate and Resilience (CR). The Envision rating system comprises four certification levels, each of which is determined by a percentage of the total Envision points that apply to each criterion. These levels are Verified (20% to 30%), Silver (30% to 40%), Gold (40% to 50%), and Platinum (50% or above). The five Envision categories, their subcategories, and their maximum achievable points are shown in Table 1 [18].

Table 1. Envision™ Categories, Subcategories, and points table

Categories	Subcategories	Max. points	
Quality of Life (QL)	Wellbeing	92	200
	Mobility	44	
	Community	64	
Leadership (LD)	Collaboration	72	182
	Planning	60	
	Economy	50	
Resource Allocation (RA)	Materials	66	196
	Energy	76	
	Water	54	
Natural World (NW)	Siting	82	232
	Conservation	78	
	Ecology	72	
Climate and Resilience (CR)	Emissions	64	190
	Resilience	126	
Total Points			1000

The Envision rating system's consideration of how the project fits with general community needs and improves the quality of life by asking the question "Are we doing the right project?" is one of its key driving forces [19]. According to ISI, this sustainability evaluation tool has several advantages for developing equitable and sustainable infrastructure, including fostering social equity and environmental justice principles in project processes and decision-making, assisting communities in becoming carbon neutral, facilitating improved stakeholder engagement and interagency collaboration, and enhancing the civil infrastructure's resilience, readiness, and long-term viability [20]. Moreover, Envision credits such as QL3.1 Advance Equity and Social Justice encourage active engagement from community stakeholders throughout the project life-cycle as well as establish thorough communication between project teams and impacted communities thus allowing them to inspect a project’s impacts from all perspectives. Likewise, other Envision credits such as QL1.2 Enhance Public Health and Safety, QL2.1 Improve Community Mobility and Access, QL2.2 Encourage Sustainable Transportation, QL3.2 Preserve Historic and Cultural Resources, LD1.3 Provide for Stakeholder Involvement, LD2.2 Plan for Sustainable Communities, LD3.1 Stimulate Economic Prosperity and Development, and LD3.2 Develop Local Skills and Capabilities encourages equitable infrastructure development [18]. Most of these credits have five levels of achievement that include Improved, Enhanced, Superior, Conserving and Restorative. These levels of achievement are assigned specific points under each credit. Table 2 highlights a brief description of the requirements necessary to meet these levels of achievement along with the assigned points for the above-mentioned Envision credits. With increasing contributions toward sustainability, the levels of achievement along with assigned points increase. The detailed description of these requirements along with evaluation criteria and documentation guidance can be found in Envision guidance manual (version 3) [18]. Some suggested improvements to the Envision rating system for enhanced social equity include offering social equity criteria more weight to encourage projects that prioritize such

considerations, adding more metrics like community engagement and job creation, and incorporating community feedback into project planning and design to help address potential social equity issues.

Table 2. Levels of achievement of Envision credits related to infrastructure equity

Envision credits	Levels of achievement				
	Improved	**Enhanced**	**Superior**	**Conserving**	**Restorative**
QL1.2 Enhance Public Health and Safety (20 points)	Understanding impacts (2 points)	Prioritizing risk reduction (7 points)	Improving health and safety (12 points)	Shared benefits (16 points)	Protecting communities (20 points)
QL2.1 Improve Community Mobility and Access (14 points)	Satisfactory coordination (1 point)	Controlled access (3 points)	Increased access and flow (7 points)	Connected Networks (11 points)	Restoring community connections (14 points)
QL2.2 Encourage Sustainable Transportation (16 points)	N/A	Access to transit or active transportation (5 points)	Encourages transit or active transportation (8 points)	Transit or active transportation programs (12 points)	New connections (16 points)
QL3.1 Advance Equity and Social Justice (18 points)	Understanding Equity (3 points)	Mitigation (6 points)	Empowerment (10 points)	Equitable access to benefits (14 points)	Equitable futures (18 points)
QL3.2 Preserve Historic and Cultural Resources (18 points)	N/A	Stakeholder consultation (2 points)	Expanded search (7 points)	Conservation (12 points)	Restoration (18 points)
LD1.3 Provide for Stakeholder Involvement (18 points)	Active engagement (3 points)	Direct engagement (6 points)	Community involvement (9 points)	Community Satisfaction (14 points)	Stakeholder Partnerships (18 points)
LD2.2 Plan for Sustainable Communities (16 points)	Sustainability Indicators (4 points)	Alternative Analysis (6 points)	Sustainability Assessment (9 points)	Sustainable Planning (12 points)	More Sustainable Communities (16 points)
LD3.1 Stimulate Economic Prosperity and Development (20 points)	New Capacity (3 points)	Improved Choices (6 points)	Business Attraction (12 points)	Development Rebirth (20 points)	N/A
LD3.2 Develop Local Skills and Capabilities (16 points)	Gaining Skills (2 points)	Growing Capacity (4 points)	Building Communities (8 points)	Long-Term Opportunities (12 points)	Community Revitalization (16 points)

Furthermore, studies on the relationship between the Sustainable Development Goals and the Envision rating system have found that objectives related to equitable infrastructure, like ending poverty (SDG 1), promoting good health and well-being (SDG 3), and reducing disparities (SDG

10), are highly compatible with the rating system [21]. Thus, introducing the CEC students to how the Envision rating system can facilitate addressing infrastructure inequity issues can help them enhance their knowledge and abilities to develop equitable and sustainable infrastructure systems. This research aims to address and mitigate the existing infrastructure inequity issues by educating the future CEC workforce and equipping them with knowledge and techniques such as leveraging Envision rating system and its relevant credits to mitigate such issues. To accomplish this aim, this study implemented training in a cross-listed sustainable construction class and assessed the students' knowledge improvement as well as captured students' change of perception about how well they can tackle these issues in their future careers. The study's findings would help raise awareness of infrastructure inequality and equip the upcoming construction workforce with the necessary competencies to ensure an equitable infrastructure system.

Methodology

This research introduced the CEC students to equitable infrastructure training to address infrastructure inequity issues as demonstrated in the research overview framework in Figure 1. The participating students of this research were enrolled in a Sustainable Approach to Construction course under the construction management program in the Summer 2022 semester. Sustainable construction is a cross-listed 3-credit elective course offered to both undergraduate and graduate level students. The course objectives included teaching the concepts and techniques of sustainable construction as well as a review of sustainable materials and techniques. The course includes a training module every semester comprising one scheduled class that covers special topics relevant to sustainability such as social sustainability, equity, environmental, social and governance (ESG), and so on. Therefore, the equitable infrastructure training module did not require the removal of any preexisting course content. The training was a standalone module that was included in the course in the later part of the semester to expose the CEC students to these topics and have a better understanding of these issues.

The objective of the training module was to improve the knowledge of the CEC students on social sustainability and relevant issues as part of sustainable construction as well as familiarize them with the Envision rating system to address these issues. However, the students were not expected to use this rating system during the remainder of the course. The students were asked to complete the pre-survey before the training. Then, the participants were instructed to watch a video developed by ISI which was provided to them by the course instructor. The video discussed topics including infrastructure inequity issues as well as how Envision rating system can address these challenges. The students were instructed to watch the video and then immediately complete the post-survey.

The participants included students from architecture, engineering, and construction majors. The training focused on helping students identify their knowledge regarding topics that include social equity, gentrification, environmental racism, and so on. Furthermore, the training introduced the students to the Envision rating system and how this rating system can address infrastructure

inequity issues. 35 CEC students from different backgrounds participated in the training, according to the findings of the presurvey. Among the participants, 77% declared themselves as Hispanic, whereas 23% were non-Hispanic students. Moreover, 6% of the students were identified as African American, 74% as white, 3% as Asian, 6% as members of more than one ethnic group, and 11% as other ethnicities.

The study conducted surveys before and after the training by utilizing an online surveying tool, Qualtrics which was used to prepare and distribute the survey among the participants. The pre-survey included multiple-choice questions, five-point Likert scale questions, and socio-demographics. The multiple-choice questions focused on recording students' existing knowledge about infrastructure inequity scenarios, gentrification, social equity, sustainable infrastructure, and Envision rating system. The Likert scale questions collected data about students' self-judgment about their understanding of identifying infrastructure inequity issues and how to address them through implementing Envision rating system. Furthermore, the demographic questions recorded the participants' social and educational backgrounds. The post-survey included the same multiple-choice questions and Likert scale questions as the pre-survey to conduct a comparative analysis and capture the differences in the students' responses due to the training.

The pre and post-survey data obtained through the multiple choice questions were analyzed using the McNemar test in the study. The McNemar test, which examines if there are differences in a dichotomous dependent variable (i.e., categorical variables with only two categories) between two related groups, is the most suitable statistical analysis for the obtained data [22]. The McNemar test was performed using SPSS with a 90% confidence interval and a maximum targeted P-value of 0.1. To further visualize the overall changes in the student's abilities to understand infrastructure equity concepts throughout the training, the study utilized box plots to show the pre-and post-survey data relating to students' self-judgment about various topics regarding infrastructure inequity.

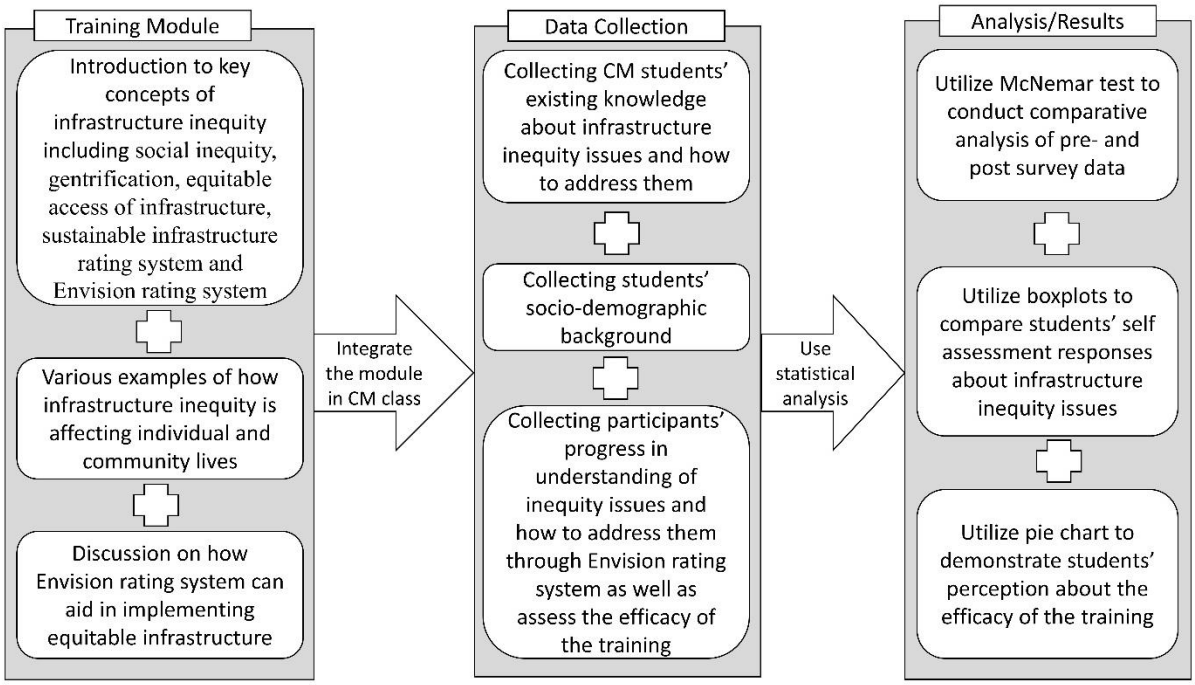

Figure 1. Research Overview

Results and Analysis

This section presents the analysis and results of students' pre and post-training knowledge and awareness of infrastructure inequity issues and how to address these issues particularly, through implementing Envision sustainability rating system. The survey respondents were from diverse socio-demographic backgrounds. Among the 35 total respondents, 27 were male and 8 were female with different ethnicity, age, and races including Asian, White, African American, and mixed race. The study assessed the students' ability to identify various equitable infrastructure concepts through the pre and post-survey. The authors utilized the McNemar test to analyze the survey responses as shown in Table 3. The findings present the calculated mean difference between several statements that were included in the pre and post-surveys. The results show that there is a significant difference between the means of the two datasets except for variables 1, 2, 4, 5, and 7. The p-value less than 0.1 for the remaining statements indicated that the training was helpful to improve students' awareness of infrastructure equity.

Table 3. Results for McNemar Test of Pre-and Post-training data

S.N.	Variables	Mean Difference	Std. Deviation	P-value
1	Pre and Post training answers for social equity.	0.08	0.355 0.236	.453
2	Pre and Post training answers for gentrification.	0.03	0.497 0.49	1.000
3	Pre and Post training answers for environmental racism.	0.23	0.497 0.49	.039
4	Pre and Post training answers for infrastructure inequity.	0.03	0.382 0.355	1.000
5	Pre and Post training answers for displacement.	0.03	0.502 0.505	1.000
6	Pre and Post training answers for infrastructure sustainability rating systems.	0.25	0.443 0.507	.064
7	Pre and Post training answers for Envision rating system to address social inequity.	0.02	0.323 0.323	1.000

Additionally, the survey questionnaire asked the students about their ability to identify infrastructure inequity concerns and how to address them. Figure 2 shows the comparison between statements in pre and post-survey using box plots where 1= strongly disagree and 5= strongly agree. The results highlighted that very few students strongly agreed to have enough knowledge of infrastructure inequity issues during the pre-survey. Apart from the statements such as “I am able to accurately define what is meant by equitable infrastructure”, and “I have learned about infrastructure equity issues through the media (TV, internet, social media, streaming, etc)” having a median value of 3, all the remaining statements had a median value of 4 during the pre-survey. However, the post-survey results indicated that after the training all other students became aware of the infrastructure inequity challenges and how to address them as characterized by the median value of 4 and 5 as shown in Figure 2.

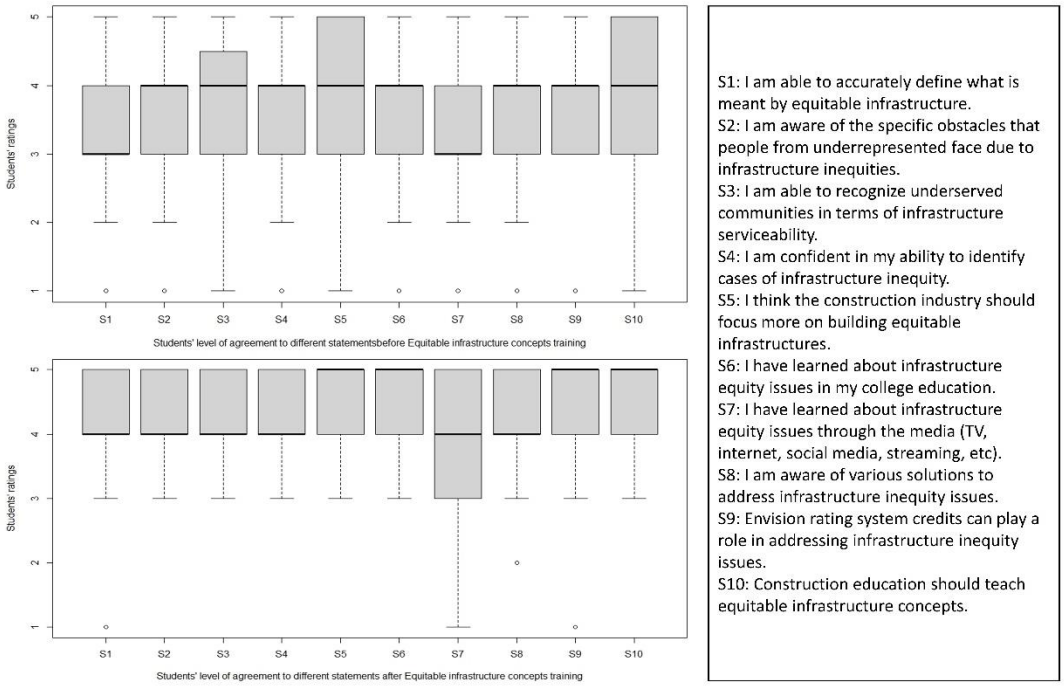

Figure 2. Boxplots showing students' level of agreement during pre and post survey

Figure 3 shows the percentages of different feedback for equitable infrastructure training. Almost 91% of the students showed positive feedback about the training, which included statements such as, "It provided a lot of new information about a concept I did not know", "The training elaborated the details about these issues including the steps to address them", and "It taught me about how pressing the infrastructure development is regarding the less fortunate population and how we have to do a better job on addressing and fixing it" among others. Although there was neither negative nor neutral feedback, 9% of students did not respond to the question.

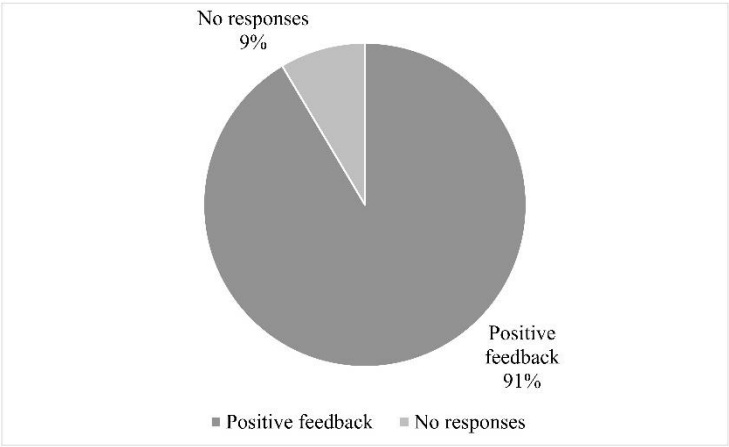

Figure 3. Pie chart for students' qualitative feedback on equitable infrastructure training

Limitations and Future Work

This study aspired to demonstrate the importance of infrastructure equity training among CEC students and improve their competency in establishing equitable infrastructure systems. However, the study acknowledges some limitations. The study implemented the training in a minority-serving institute which may not be representative of all STEM institutions. Additionally, the survey responses might be subjective to self-assessment and biases. Therefore, to assess the effectiveness of the intervention, future studies might concentrate on integrating training across several institutions with various socio-demographic backgrounds. Furthermore, to accomplish long-lasting change, such training must be included in every semester along with thorough evaluation, engagement, and monitoring.

Conclusion

To reinforce the social dimension of sustainability, professionals must become competent to eradicate infrastructure inequity and establish equitable infrastructure systems. To accomplish this goal, civil engineering, and construction educators must incorporate adequate classes and workshops that improve future workers' competence and awareness of such issues and their resolution. This study intends to demonstrate to the CEC students the importance of equitable infrastructure and how techniques such as leveraging the Envision rating system can potentially aid in addressing infrastructure inequity issues. The study also assesses the knowledge improvements of the participating students and captures students' feedback on the efficacy of the training. According to the pre-and post-survey results, the awareness of infrastructure inequity issues among the CEC students had significantly improved, as shown by the increased median value of box plots and favorable comments. Thus, the study suggests that similar effective approaches might be included in other programs to enhance awareness among future professionals. The results of this study advance social sustainability education by promoting equitable infrastructure concepts among CEC students and raising awareness of the social aspect of sustainability within the future engineering workforce.

References

[1] White House, "President Biden's Bipartisan Infrastructure Law | The White House," 2021. [Online]. Available: https://www.whitehouse.gov/bipartisan-infrastructure-law/. [Accessed: 31-Jan-2022].

[2] J. Norman, "Biden ' s $ 1 . 2 trillion infrastructure bill is good policy – and good politics." pp. 1–2, 2021.

[3] L. Carey, S. J. Naimoli, and M. Higman, "The American Jobs Plan Gets Serious about Infrastructure and Climate Change." 2021, doi: http://119.78.100.173/C666/handle/2XK7JSWQ/321229.

[4] J. Elkington, "Accounting for the Triple Bottom Line," *Meas. Bus. Excell.*, vol. 2, no. 3, pp. 18–22, 1998, doi: 10.1108/eb025539.

[5] R. Rahat, V. Ferrer, P. Pradhananga, and M. ElZomor, "Assessing pedagogical paradigm

for coupling FEP and sustainability practices." Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2021, doi: https://doi.org/10.3886/E152102V1.

[6] ISI, "Envision Rating System for Sustainable Infrastructure." Washington, DC, 2015.

[7] M. Elzomor, R. Rahat, P. Pradhananga, and C. C. Müller, "A step towards nurturing equitable and sustainable infrastructure systems," in *ASEE 2022 Annual Conference*, 2022.

[8] H. Pearsall *et al.*, "Advancing equitable health and well-being across urban–rural sustainable infrastructure systems," *npj Urban Sustain.*, vol. 1, no. 1, pp. 1–6, 2021, doi: 10.1038/s42949-021-00028-8.

[9] N. D. McWhirter and T. Shealy, "Teaching decision-making for sustainable infrastructure: a wind energy case study module," *Int. J. Sustain. High. Educ.*, vol. 19, no. 5, pp. 893–911, 2018, doi: 10.1108/IJSHE-10-2017-0183.

[10] N. McWhirter and T. Shealy, "Case-based flipped classroom approach to teach sustainable infrastructure and decision-making," *Int. J. Constr. Educ. Res.*, vol. 16, no. 1, pp. 3–23, 2020, doi: 10.1080/15578771.2018.1487892.

[11] ASCE, "The Vision for Civil Engineering in 2025," *Am. Soc. Civ. Eng.*, vol. 18, no. 4, pp. 651–660, 2007.

[12] C. W. Bolding, J. H. Ogle, and L. J. Rapa, "Exploring Undergraduate Civil Engineering Students' Perceptions of Infrastructure Inequities: A Pilot Study," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2021.

[13] R. Oulton, T. G. Gallagher, and C. K. Anovick, "Efficacy of Curricular Enhancements to Address Social and Environmental Injustice in Civil Engineering," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2021.

[14] D. E. Armanios *et al.*, "Diversity, Equity, and Inclusion in Civil and Environmental Engineering Education: Social Justice in a Changing Climate," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2021.

[15] R. Valdes-Vasquez, A. Pearce, and C. Clevenger, "Teaching social sustainability in Sustainable Construction and Infrastructure courses: A collaborative approach," *Constr. Res. Congr. 2012 Constr. Challenges a Flat World, Proc. 2012 Constr. Res. Congr.*, pp. 2129–2138, 2012, doi: 10.1061/9780784412329.214.

[16] K. E. Björnberg, I. B. Skogh, and E. Strömberg, "Integrating social sustainability in engineering education at the KTH Royal Institute of Technology," *Int. J. Sustain. High. Educ.*, vol. 16, no. 5, pp. 639–649, 2015, doi: 10.1108/IJSHE-01-2014-0010.

[17] R. Rahat, V. Ferrer, P. Pradhananga, and M. ElZomor, "Developing an effective front-end planning framework for sustainable infrastructure projects," *Int. J. Constr. Manag.*, vol. 0, no. 0, pp. 1–18, 2022, doi: 10.1080/15623599.2022.2105282.

[18] ISI, "Envision: Sustainable Infrastructure Framework Guidance Manual." Institute for Sustainable Infrastructure, Washington, DC, p. 192, 2018.

[19] M. B. Reiner, S. Fisher, and J. Sperling, “Evaluation of sustainable infrastructure: Development context matters,” *ICSI 2014 Creat. Infrastruct. a Sustain. World - Proc. 2014 Int. Conf. Sustain. Infrastruct.*, pp. 420–433, 2014, doi: 10.1061/9780784478745.037.

[20] ISI, “The Blueprint for Sustainable Infrastructure.” 2021.

[21] C. Contreras, “Creating a Common Language: How Does the Sustainable Infrastructure Criteria Compare to the SDGs?,” *Int. Conf. Sustain. Infrastruct.*, no. Zimmerman 2014, pp. 14–25, 2019.

[22] M. Q. R. Pembury Smith and G. D. Ruxton, “Effective use of the McNemar test,” *Behav. Ecol. Sociobiol.*, vol. 74, no. 11, 2020, doi: 10.1007/s00265-020-02916-y.