Exploring Civil Engineering and Construction Management Students' Perceptions of Equity in Developing Infrastructure Resilience

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Abstract

Recent years have seen a substantial shift in the field of civil engineering (CE) and construction management (CM) education and workforce development, with an increased emphasis on sustainability and resilience. Sustainability considers economic, ecological, and social aspects while addressing problems pertaining to human welfare, the environment, and community impact. Resilient infrastructure maintains both structural and functional integrity while supporting interdependent social, transportation, water, and energy systems, even after catastrophic disasters. Although many civil engineering programs address sustainability, resiliency is rarely discussed in these courses. Furthermore, it is critical to look into how CE and CM students comprehend the relationships between social justice and our infrastructure systems, considering the increasing significance of these issues in our society. Comparing the awareness of societal inequalities within resilient infrastructure systems between CE and CM students can help identify potential gaps in knowledge and understanding within these distinct disciplines. Therefore, this study aims to address the following research questions: (1) Which majors/group between CE or CM students, demonstrates a greater awareness of societal inequalities within resilient infrastructure systems? (2) Is there any relation between the understanding and awareness of infrastructure resilience inequality and the students being in various majors (CE and CM)? (3) Which majors/group between CE or CM students are more driven to promote systemic change as future engineering professionals? The study surveyed 51 students who were enrolled in a sustainable approach to construction course in the Fall 2023 semester. The survey gathered data for the study measuring students' awareness of equity in resilient infrastructure systems, their desire to promote systemic change and relevant demographics. The results showed that CE students were more aware of infrastructure disparities as well as they had a higher motivation to work toward systemic change compared to CM students. This study highlights the disparities in awareness of equitable infrastructure resilience between CE and CM students which can motivate the educators to develop targeted strategies and educational modules, ensuring that students in both CE and CM possess the essential knowledge and perspectives to develop equitable, sustainable, and resilient infrastructures. Since this study was limited to one educational institution, the findings might not apply to other settings. Nonetheless, this study offers a model of a methodology that can be implemented at other institutions to discover gaps and disparities amongst student groups and inspire relevant institution-specific approaches to address these gaps and disparities.

Introduction and Background

Communities across the United States are increasingly experiencing the devastating impacts of extreme weather events and changing climate conditions. The National Oceanic and Atmospheric Administration reports that in 2021 alone, there were 20 weather disaster events causing losses

exceeding $1 billion each [1]. Such disasters lead to damaged structures and infrastructure systems disrupting social services and resulting in massive financial losses. Therefore, communities ought to consider resilience actions ahead of disasters, including preparing resources, response, and recovery activities [2]. Moreover, extreme weather events and other natural disasters can have a disproportionately negative impact on low-income communities, Indigenous populations, and communities of color due to decades of discriminatory policies and practices. For example, low-income and communities of color in Houston were disproportionately affected by Hurricane Harvey's floods [3]. Therefore, engineers and construction professionals must consider marginalized communities and underrepresented groups in the resilient infrastructure development processes associated with hazard risks. Enhanced equality has the potential to boost community adaptability and lessen the unequal allocation of losses and damages resulting from extreme events.

The concept of resilience has gained significant attention focusing on effectively managing disruptions, challenges, and shocks within systems, particularly in disaster risk management [4]. It involves the ability to plan for, absorb, recover from, and adapt to adverse events [5]. However, communities of color and other marginalized and socially vulnerable groups frequently lack the resources and expertise necessary to participate in risk mitigation, planning, and reduction, or are overlooked in planning by governments and other policy and decision-makers. Additionally, well-established institutions, like state and federal agencies, local government officials, public planners, and infrastructure development companies, can be inherently biased toward inequality. These institutions often fail to acknowledge these biases which eventually leads to failure in creating equitable infrastructure resilience [6]. Recognizing the injustices that have developed over years of practice, it is necessary to address the basic social inequalities through resilience education, particularly for civil engineering (CE) and construction management (CM) students, which can, in turn, help to improve community resilience and adaptability equitably in the future.

Traditional approaches to resilience often concentrate on immediate services, security, and infrastructure without addressing underlying systemic inequalities. In order to attain equitable resilience, CE and CM professionals need to challenge and transform the systemic structures that perpetuate vulnerabilities within communities [7]. This means eliminating discriminatory practices, addressing social and economic disparities, and ensuring that resilience strategies benefit all segments of society. In order to enable systemic change, governance innovations, foresight processes, knowledge transfers, and learning-by-doing are required [8]. Additionally, skills and capacity building within a workforce can create systemic change that carries over to future projects [9]. There is also a need to learn from past approaches and past failures so that resilience can deliver genuine systemic change that empowers and benefits poor and marginalized people [10]. Without embracing systemic change, the risk remains of reinforcing existing vulnerabilities and failing to address the root causes that leave certain populations disproportionately exposed to the impacts of crises and disasters. Thus, the call for systemic change should be paramount for future CE and CM workforce in the pursuit of building resilient and equitable infrastructure for the benefit of all.

The Accrediting Board for Engineering and Technology (ABET) exclusively accredits engineering programs, while the accreditation of construction management (CM) programs is conducted by the American Council for Construction Education (ACCE). Traditionally, construction education in the United States focused on managerial, technical, and procedural aspects. However, in the past decade, the industry's environmental impact has gained recognition, prompting owners to demand the integration of sustainability in the construction process [11]. Acknowledging this shift, construction programs are now incorporating sustainability-related courses into their curricula [12]. ACCE standards mandate that construction management graduates understand the basic principles of sustainable construction [13]. Likewise, recent changes in ABET Engineering Accreditation Criteria (EAC) underline the importance of sustainability, risk, resilience, diversity, equity, and inclusion in addressing civil engineering (CE) challenges [14]. To meet these evolving criteria, design solutions must now consider risk assessment, societal and environmental impacts, relevant codes, standards, regulations, sustainability, and resilience [15]. Therefore, it is crucial to understand and enhance the awareness of CE and CM students about equity in developing sustainable and resilient infrastructure. Such awareness of equity ensures that these professionals consider the diverse needs, vulnerabilities, and priorities of all community members, promoting fairness and inclusivity in infrastructure development.

A review of the literature highlights that resilience teaching efforts often prioritize designing resilient systems such as an urban area, infrastructure, or community, that are affected by hazards or threats [16]. Some studies investigating challenges and gaps in civil engineering and construction students' knowledge of sustainability and resilience concluded that engineering curricula did not sufficiently integrate these topics, leading to insufficient understanding and knowledge regarding community and infrastructure resilience [17], [18]. However, very few literature focused on integrating the social aspect of resilience within engineering education. McDermott and Nadolski [19] presented a tool to the systems engineering students addressing both individuals' and communities' resilience. Lucena [20] focuses on the structural issues that poor communities face, which include hunger, violence, and climate change. Bielefeldt and Silverstein [21] provided various approaches for incorporating environmental justice themes such as systemic racism and community resilience into environmental and civil engineering courses where students were required to examine the organizational, social, economic, and technical aspects of the resilience of various system components. Nonetheless, there exists a literature gap concerning how students in CE and CM perceive the connections between social justice and infrastructure resilience. Addressing this gap ensures that individuals in both CE and CM fields possess a thorough understanding of social equity issues as well as contribute to the cultivation of professionals who are well-rounded and socially conscious in their respective disciplines.

Sustainability and resilience are becoming more important for both students and the employers hiring them upon graduation. especially in programs such as CE and CM. The focus on social, economic, and environmental justice is growing rapidly due to heightened awareness, and ethical considerations. While the efforts at the curriculum level to promote sustainability and resilience

have been increasing, it is not yet fully determined how effective these approaches are in advancing the awareness of social equity of the CE and CM students. This study aims to address the following research questions: (1) Which majors/group between CE or CM students, demonstrates a greater awareness of societal inequalities within resilient infrastructure systems? (2) Is there any significant relationship between the understanding and awareness of infrastructure resilience inequality and the students being in various majors (CE and CM)? (3) Which majors/group between CE or CM students are more driven to promote systemic change as future engineering professionals? To achieve these goals, this study surveyed and compared the awareness of social equity of CE and CM major students studying in a public university. The findings of this research can contribute to identifying gaps in social equity awareness between CE and CM major students which can guide the development of targeted educational modules, ensuring that both CE and CM students are well-equipped with the necessary knowledge and perspectives of equitable infrastructure resilience.

Methodology

This research investigated how CE and CM students comprehend the relationships between social justice and infrastructure systems in the context of developing disaster resilience. To achieve this objective, the study surveyed students who were enrolled in a Sustainable Approach to Construction course under the construction management program in the Fall 2023 semester. Sustainable construction is a cross-listed 3-credit elective course offered to both undergraduate and graduate level students. An online surveying tool, Qualtrics, was used to prepare and distribute the survey among the participants. The survey was divided into three parts. In part one, the survey presents the students with a story concerning a social problem that focuses on inequity in infrastructure resilience. After the story, there were two open-ended questions to evaluate students' understanding of the problem which included: (1) What issue do you believe is illustrated in this scenario? and (2) What measures can be taken to overcome this problem? In part two, the survey asked five-point Likert scale questions related to students' awareness of equitable infrastructure resilience and their interest in systemic change. In part three, the students were asked questions related to their socio-demographic information.

Survey data was collected for the current study through convenience sampling. Participants in this method were chosen according to their convenience and accessibility. In particular, those who took part in the study were registered students for the Fall semester of 2023 in the cross-listed Sustainable Approach to Construction course. This indicates that participants were selected from among the students who decided to enroll in that course for that particular academic year. The Institutional Review Board (IRB) at the university reviewed the survey and deemed the survey exempt beyond the initial review. All students were informed that the survey was optional, and they could choose to withdraw at any time without penalty.

Table 1 demonstrates socio-demographic backgrounds, including gender, age, origin, ethnicity, highest level of education, current class standing, current GPA and employment status of the total participants as well as the break-up of the CE and CM students. These sociodemographic questions included multiple-choice responses. Table 1 includes the categories of

sociodemographic factors, the questions included in the survey, the multiple-choice options, and the proportion of survey respondents who identified with each factor. Fifty-one CE and CM students from different backgrounds participated in the study, according to the findings of the survey. Among the total participants, 63% declared themselves as Hispanic, whereas 37% were non-Hispanic students. Moreover, almost 8% of the respondents were identified as African American, 63% as white, 16% as Asian, and 12% as other ethnicities. Among the CE students, 70% students had bachelor's degree, 60% had GPA ranging 3.5-3.99 and 60% had full time job. Among the participating CM students, 46% had bachelor's degree and 73% were working full time during the time of the survey took place.

Table 1: Socio-demographics of the participants (n=51)

Category	Survey Question	Response options	Count		
			Total	CE Majors	CM Majors
Gender	With what gender do you identify?	Male	37	6	31
		Female	13	3	10
		Other	1	1	0
Age	What is your age?	18 - 24	25	1	24
		25 - 34	21	8	13
		35 - 44	3	1	2
		45 - 54	2	0	2
		55 or older	0	0	0
Hispanic, Latino, or Spanish origin	Are you of Hispanic, Latino, or Spanish origin?	Yes	32	7	25
		No	19	3	16
Ethnicity	How would you describe your ethnicity? Please select all that apply.	White	32	6	26
		Black or African American	4	1	3
		American Indian or Alaska Native	1	1	0
		Asian	8	1	7
		Native Hawaiian or Pacific Islander	0	0	0
		Other	6	1	5
Highest level of Education	What is the highest level of education you have completed?	Some high school or less	0	0	0
		High school diploma or GED	3	1	2
		Some college, but no degree	7	0	7

		Associates or technical degree	8	0	8
		Bachelor's degree	26	7	19
		Graduate or professional degree	7	2	5
		Prefer not to say	0	0	0
Current class standing	What is your current class standing?	Freshman	0	0	0
		Sophomore	1	0	1
		Junior	2	0	2
		Senior	18	0	18
		Graduate	30	10	20
		Other	0	0	0
Current GPA	What is your current GPA (Grade Point Average)?	4.0 or above	3	3	0
		3.5 - 3.99	26	6	20
		3.0 - 3.49	14	0	14
		Below 3.0	5	1	4
		Prefer not to say	3	0	3
Employment status	What is your current employment status?	Employed full time	36	6	30
		Employed part time	5	1	4
		Student	8	2	6
		Self-employed	2	1	1

The study conducted a mixed-method analysis of the collected survey responses. Qualitative content analysis was performed on open-ended responses. The content analysis involved manual keyword search analysis which included keywords such as equity/ inequity/ racism/ disparity/ fair/ unfair/ prioritization/ equality/ segregation/ preferences/ negligence/ bias/ discrimination/ overlooked/ socio-economic advantage/ inequality to find instances of equitable resilience in the responses. Furthermore, this study utilized binary logistic regression to examine the correlation between awareness of equitable resilience and the academic majors of the study participants, aiming to assess and compare the level of awareness between CE and CM students. The majors of the students were regarded as a binary variable, with (1) denoting CM majors and (0) denoting CE majors. A binary logistic regression analysis was selected since it analyzes a dependent variable with two possible values (i.e., CE/CM) represented by indicator variables. This study has binary variables as indicator variables where the values are either 1 or 0. For this study, the parameters are defined as follows: X_M is the Major of the participants; V1 to V10 are ten statements related to awareness of equitable infrastructure resilience. Afterwards, the SPSS tool was used to estimate the values of regression coefficients and the p-value from the t-test.

The binary logistic regression model utilizes these parameters through the following equation:

$$X_M = \beta_o + \beta_1 * V1 + \beta_2 * V2 + \beta_3 * V3 + \beta_4 * V4 + \beta_5 * V5 + \beta_6 * V6 + \beta_7 * V7 + \beta_8 * V8 + \beta_9 * V9 + \beta_{10} * V10 + \varepsilon \quad (1)$$

β0, to β10 in the above equation are regression coefficients that correlate between each parameter and the participants' Majors. The p-value indicates the confidence level, in terms of correlation, of each variable with the dependent variable. The confidence interval in the analysis is assumed to be 90% for this study. Moreover, literature has demonstrated the effectiveness of boxplots for presenting Likert Scale survey responses [22], [23]. Hence, this study utilized boxplots to analyze the 5-point Likert scale survey responses to demonstrate and compare the interest of CE and CM students toward contributing to systemic change.

Results

This section presents the results of the survey responses collected through this research. The authors manually analyzed the two open-ended questions to determine the ability of the CE and CM students to recognize issues related to inequity. The responses having one or more of the keywords mentioned in the Methodology section were considered as "Presence of inequity issue". If none of these keywords were found in the responses, then the answers were considered as "Absence of inequity issue". Figure 1 shows the responses of both CE and CM majors. The bar chart shows that all ten CE students could identify the inequity issue whereas 31 out of 41 CM students (75%) could identify the inequity issue. This may indicate that CE students are more aware of existing inequity issues compared to CM students.

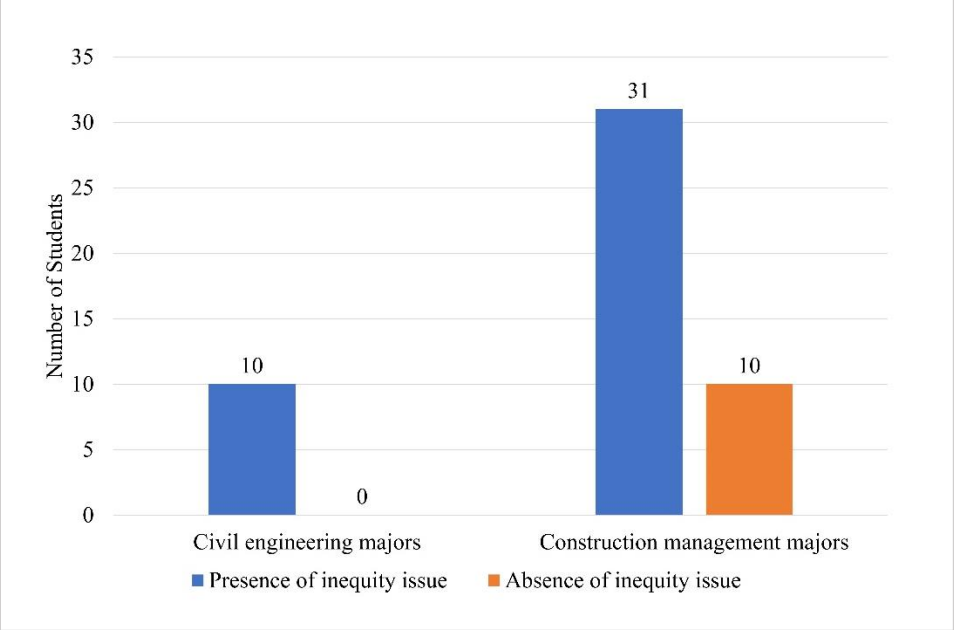

Figure 1. Ability of Civil Engineering (CE) and Construction Management (CM) majors to recognize issues related to inequity

A binary logistic regression model was performed to determine which independent variables (statements related to equitable infrastructure resilience) have a statistically significant effect on the dependent variable (CE/CM Majors). The results highlighted that variables 3 and 8 have a significance value of less than 0.1 as shown in Table 2. The regression coefficient (β) values for variables 3 and 8 are -3.696 and -2.699 respectively. These coefficients suggest that the likelihood of possessing awareness regarding social injustices and inequities within infrastructure projects, as well as engaging in the study of case studies emphasizing equity and social justice in resilient infrastructure systems, is greater for CE students compared to CM students. These results indicate that the educational background of CE students may contribute to a more pronounced understanding of societal inequalities within infrastructure systems compared to CM students.

Table 2. Values of Regression Coefficients and Significance Test for Binary Logistic Regression Model

Sl.	Variables	β	Sample Error (S.E.)	Wald	Degree of Freedom (DF)	P-value	Exp (β)
V1	Awareness of communities within your region that are more vulnerable to natural disasters and climate change impacts (1 if more than moderate, 0 otherwise)	2.283	1.622	1.98	1	0.159	9.806
V2	Aware of specific social or economic factors that make certain communities more susceptible to infrastructure-related vulnerabilities	-20.193	7784.06	0	1	0.998	0
V3	Awareness of social injustices and inequities within infrastructure projects	-3.696	2.169	2.903	1	0.088	0.025
V4	Encountering situations where social inequalities influenced engineering decisions during your studies or work experiences	1.816	1.562	1.353	1	0.245	6.149
V5	Ability to define resilient infrastructure in	22.476	7784.061	0	1	0.998	5.77E+09

	the context of natural disasters						
V6	Ability to provide examples of resilient infrastructure projects that have successfully addressed societal inequalities in vulnerable communities	-0.46	1.58	0.085	1	0.771	0.632
V7	Extent of civil engineering/construction management program covering topics related to equity in developing resilient infrastructure	1.094	1.288	0.722	1	0.396	2.987
V8	Study of case studies or projects that focus on ensuring equity and social justice in resilient infrastructure systems	-2.699	1.439	3.517	1	0.061	0.067
V9	Importance to consider social equity in the planning and implementation of resilient infrastructure projects	1.436	1.482	0.94	1	0.332	4.204
V10	Extent of the lack of access to transportation affects the overall resilience of a community during and after a disaster	37.133	11587.81	0	1	0.997	1.34E+16
	Constant	1.231	0.788	2.445	1	0.118	3.426

Furthermore, the study utilized boxplots to compare the CE and CM students' responses related to their interest in working toward systemic change as shown in Figure 2. The students were allowed to rate their level of interest from 1 to 5 (1 = None at all, 2 = Slightly, 3 = Moderately, 4 = Greatly, 5 = Significantly) on eight statements. Boxplots were created using R-Studio to showcase the participants' level of interest. The findings highlighted that CE students' responses had a median value ranging from 4.5 to 5 for all the statements. On the other hand, CM students had a median value of 4 for all the statements except S4, S5, and S8 which have a median value of 3. This suggests that CE students are more inclined to specialize in engineering fields that explicitly address social justice concerns, as indicated in S4. Additionally, CE students exhibit a greater willingness to advocate for social justice within engineering projects and challenge established practices, as evidenced by their responses to S5. Moreover, responses to S8

underscored that CE students feel more empowered to support such initiatives compared to their CM counterparts. In summary, the findings suggest that CE students exhibit a greater readiness to contribute to systemic change compared to CM students.

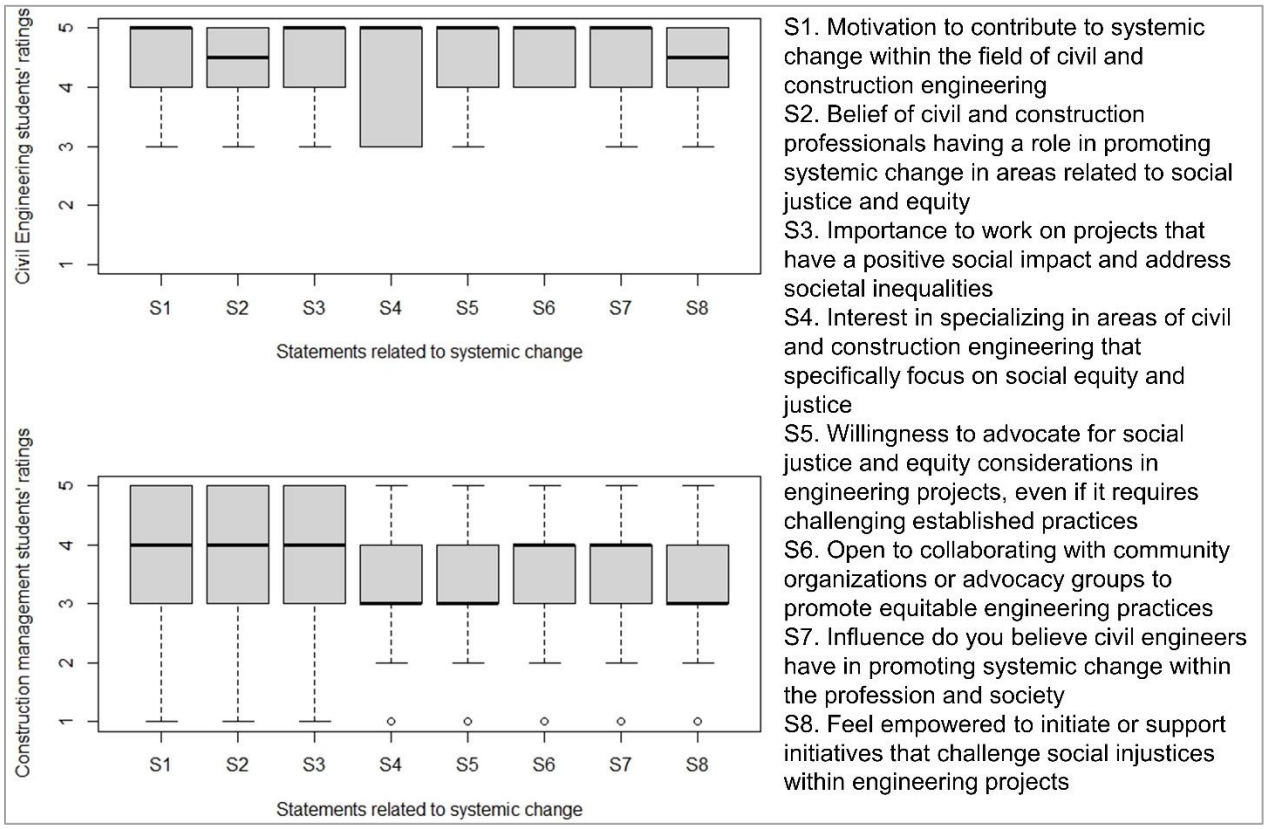

Figure 2. Boxplots comparing the CE and CM students' responses related to their interest in working toward systemic change (1 = None at all, 2 = Slightly, 3 = Moderately, 4 = Greatly, 5 = Significantly)

Limitations and Future Works

This research acknowledges some limitations. Participants may provide responses based on self-assessment, which can be influenced by personal perspectives, experiences, and perceptions. Additionally, convenience sampling may impose some restrictions on how broadly the results can be applied because it does not guarantee that the sample is representative of the total population but rather only includes those who were most easily accessible or available to participate in the study. Moreover, statistical significance in the binary logistic regression model was marginal. Nonetheless, this study provides a novel insight into CE and CM students' perceptions of equity in the infrastructure resilience context and can be used as a foundation for future studies. Future studies can consider more data such as multiple years, more students and more in-depth student demographic data such as family income or average income in home zip code to provide a more comprehensive perspective on the state of the awareness of equitable and resilient infrastructure. Future research can also investigate more in-depth questions to understand the reason behind the difference between CE and CM students, along with utilizing

different other statistical analysis of the collected data to examine the observed perceptions obtained in this research.

Conclusion

Infrastructure systems and buildings need to be both functional and resistant to hazards for a community to thrive. It is becoming critical for universities to be active in sustainable and resilient education as it empowers students to contribute to developing sustainable and resilient infrastructure projects. Likewise, it is critical to enhance the awareness of future CE and CM professionals about equity while developing such projects. Such knowledge and awareness can allow them to gain the ability to offer valuable feedback to project teams and contribute to decision-making processes while embracing equity. This study delivers value to both the industry and academic community by highlighting the need to educate the CE and CM students to fortify the foundation of infrastructure equity knowledge, particularly in the context of disaster resilience. The results suggest that the students who had CE majors are more aware of equitable and resilient infrastructure than their peers who have CM majors. Additionally, CE students are more willing to work towards systemic change compared to CM students. Thus, it can be concluded that CM curricula need to put a higher emphasis on incorporating equitable sustainability and resilient courses to instigate enhanced awareness among students. In order to promote such awareness, universities can focus on creating and implementing sustainable, equitable, and resilient infrastructure-related courses in CE and CM curricula and ensure that students are well-equipped to address societal inequalities within the domain of sustainable and resilient infrastructure. This research was conducted in a single institution therefore the results might not be transferrable to other institutions. However, this paper provides a model of an approach that can be used at other institutions to identify gaps and disparities between groups of students and motivate appropriate institution-specific strategies to address these gaps and disparities.

References

[1] NOAA, "U.S. Billion-Dollar Weather and Climate Disasters," *National Centers for Environmental Information (NCEI)*, 2023. [Online]. Available: https://www.ncei.noaa.gov/access/billions/.

[2] R. Adam, *Defining and Measuring Economic Resilience from a Societal, Environmental and Security Perspective*. Singapore: Springer, 2017.

[3] N. Coleman, A. Esmalian, and A. Mostafavi, "Equitable Resilience in Infrastructure Systems: Empirical Assessment of Disparities in Hardship Experiences of Vulnerable Populations during Service Disruptions," *Nat. Hazards Rev.*, vol. 21, no. 4, p. 04020034, 2020, doi: 10.1061/(asce)nh.1527-6996.0000401.

[4] National Research Council, *Disaster Resilience*. Washington, D.C.: National Academies Press, 2012.

[5] R. Rahat, P. Pradhananga, C. Calle Muller, and M. ElZomor, "Multi-criteria evaluation of

Safe-to-Fail flood solution alternatives for developing resilient coastal cities," *Sustain. Resilient Infrastruct.*, vol. 8, no. 6, pp. 610–625, 2023, doi: 10.1080/23789689.2023.2257503.

[6] National Academics, "Equitable and Resilient Infrastructure Investments," The National Academies Press, Washington, DC, 2022.

[7] R. Rahat, P. Pradhananga, and M. ElZomor, "A step toward nurturing infrastructure sustainability and rating systems through construction management curricula," *Int. J. Sustain. High. Educ.*, vol. 24, no. 8, pp. 1878–1897, 2023, doi: 10.1108/IJSHE-09-2022-0296.

[8] M. Wolfram and N. Frantzeskaki, "Cities and systemic change for sustainability: Prevailing epistemologies and an emerging research agenda," *Sustain.*, vol. 8, no. 2, 2016, doi: 10.3390/su8020144.

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

[10] T. Tanner, A. Bahadur, C. Simonet, and H. Betts, "Resilience scan | 2014," 2016.

[11] B. G. Celik, M. E. Ozbek, S. Attaran, and M. Jalili, "Comparison of Environmental Responsibility of Construction Management Students Based on Exposure to Sustainability in Curricula and on Campus," *Int. J. Constr. Educ. Res.*, vol. 10, no. 2, pp. 96–110, 2014, doi: 10.1080/15578771.2013.826752.

[12] A. Tinker and R. Burt, "'Greening' the construction curriculum," *Int. J. Constr. Educ. Res.*, vol. 1, no. 1, pp. 26–33, 2003.

[13] ACCE, "Standards and criteria for accreditation of postsecondary construction education degree programs," 2021.

[14] ABET, "Criteria for Accrediting Engineering Programs," *Criteria for accrediting engineering programs*. p. 3, 2024.

[15] L. R. Brunell, "Integrating the united nations sustainable development goals and the envision rating system to assess sustainability in civil engineering capstone design," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2020-June, 2020, doi: 10.18260/1-2--34848.

[16] A. K. Winkens and C. Leicht-Scholten, "Does engineering education research address resilience and if so, how?–a systematic literature review," *Eur. J. Eng. Educ.*, vol. 48, no. 2, pp. 221–239, 2023, doi: 10.1080/03043797.2023.2171852.

[17] N. Salzman, B. C. S. Chittoori, S. M. Miller, and T. A. Robbins, "Senior Civil Engineering Students ' Views on Sustainability and Resiliency," 2018.

[18] S. Rokooei, F. Vahedifard, and S. Belay, "Perceptions of Civil Engineering and Construction Students Toward Community and Infrastructure Resilience," *J. Civ. Eng. Educ.*, vol. 148, no. 1, pp. 1–12, 2022, doi: 10.1061/(asce)ei.2643-9115.0000056.

[19] T. McDermott and M. Nadolski, "Training systems engineers to model sociotechnical aspects of complex engineered systems," *12th Annu. IEEE Int. Syst. Conf. SysCon 2018 -*

Proc., pp. 1–8, 2018, doi: 10.1109/SYSCON.2018.8369604.

[20] J. C. Lucena, "Can community development projects in engineering education be both responsible and sustainable?: Theory, education, and praxis," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2020-June, 2020, doi: 10.18260/1-2--34254.

[21] A. R. Bielefeldt and J. A. Silverstein, "Environmental Justice and Equity Issues: In Our Backyards and Beyond," in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2021.

[22] M. Elzomor, P. Pradhananga, and A. M. Sadri, "Using social media to improve minority students' skills when connecting courses with different educational modalities," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2020-June, 2020, doi: 10.18260/1-2--35472.

[23] P. Pradhananga, M. ElZomor, and G. Santi Kasabdji, "Identifying the Challenges to Adopting Robotics in the US Construction Industry," *J. Constr. Eng. Manag.*, vol. 147, no. 5, pp. 1–10, 2021, doi: 10.1061/(asce)co.1943-7862.0002007.