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Exploring Undergraduate Civil Engineering Students' Perceptions of Infrastructure Inequities: A Pilot Study

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Abstract

As social justice issues facing our nation continue to be placed in the foreground of everyday life, it is important to understand how undergraduate civil engineering students perceive and understand relations between social justice and our infrastructure systems. Additionally, as more civil engineering undergraduate programs increase the emphasis on ethics and equity issues in their curricula, we must also seek to understand students' awareness of their influence, as civil engineering professionals, to improve infrastructure systems that contribute to injustice and inequity.

This paper presents findings from a pilot study conducted as part of an NSF-funded grant implementing cultural and curricular changes in a medium-sized civil engineering department in the southeast. Drawing on frameworks that examine how individuals critically understand systems of oppression, and the justification used to explain these systems this work examined student perceptions of inequities in societal infrastructure systems. The present study was guided by the following research questions: (1) Are undergraduate civil engineering students critically aware of inequities in society's infrastructure systems? (2) To what degree are undergraduate civil engineering students comfortable challenging the status quo? (3) Is there an association between students' critical awareness of inequitable infrastructure systems and their agency to promote systemic change as civil engineering professionals?

Study data included survey responses to validated scales measuring: critical consciousness, system justification beliefs, social empathy, and sociopolitical control beliefs. New instrumentation was also piloted assessing equity-related perceptions and beliefs about civil engineering and infrastructure systems. Participants were junior and senior undergraduate civil engineering students (n = 21) enrolled in a professional development, community, and strategic change course, with data collected throughout the Fall 2020 semester. Results suggest that students did have awareness of infrastructure inequities and, on average, did not have strong system justification beliefs. However, there was not an association between students' awareness of inequities and their agency beliefs about promoting systemic change as civil engineers. After presenting study results, we discuss implications of study results and propose directions for future research.

Introduction

As social justice issues facing our nation continue to make their way to the foreground of everyday life, it is more important than ever to understand how undergraduate civil engineering students perceive and understand relations between social justice and our infrastructure systems. Additionally, as more civil engineering undergraduate programs modify their curricula to include greater emphasis on ethics and equity issues, we must also seek to understand students'

awareness of their agency, as civil engineering professionals, to improve infrastructure systems that contribute to injustice and inequity.

Civil engineering is, as its name implies, about the design, construction, and maintenance of civil infrastructure to fulfill the needs of society such as clean water, safe shelter, waste treatment, and transportation mobility. In the early 1900s, the American Society of Civil Engineers developed the first code of ethics which has evolved over time to focus on the paramount task of ensuring the health and welfare of the public. However, only recently in 2017 did the code include Canon 8 stating, "Engineers shall, in all matters related to their profession, treat all persons fairly and encourage equitable participation without regard to gender or gender identity, race, national origin, ethnicity, religion, age, sexual orientation, disability, political affiliation, or family, marital, or economic status." (ASCE, 2017) Unfortunately, this change comes after decades of infrastructure development based on land use codes and financial policies that created vastly disparate effects for lower-income, marginalized, and otherwise vulnerable communities.

A key ingredient in the disparity was defined by "redlining' practices. Amidst the great depression in the 1930s, the federal government's Home Owners Loan Corporation (HOLC) color-coded communities on maps based on their perceived level of financial risk [2]. Affluent white population areas were deemed low-risk and offered access to financing, while communities of racial and ethnic populations were noted as moderate- to high-risk areas and marked in red. These planning and financial policies essentially devalued properties in high-risk areas and limited access to financial resources for residents of these areas. What resulted was limited development of amenities (e.g., parks, landscaping, and sidewalks) and excess development of major infrastructure (e.g., freeways, major arterials, and industrial facilities) in the devalued areas. The combination of which creates untenable consequences for its residents including vast amounts of paved surfaces creating urban heat islands; proximity to high levels of vehicle emissions and degraded air quality; increased fatalities from crossing at midblock locations where there is limited pedestrian access; and more recently, effects of gentrification pushing residents away from transit-friendly city centers to rural areas which leaves them transportation disadvantaged.

Despite having valid case studies and resources on the socio-political concerns related to civil infrastructure from the Environmental Protection Agency's Environmental Justice site to the development of open-source databases for Mapping Inequality, few civil engineering programs have adopted this content in classes. Instead, faculty members often prefer to focus on the technical aspects of civil infrastructure and rely on students connecting content from courses outside the major to develop critical awareness of these inequitable practices. However, it is imperative that civil engineering courses provide spaces for students to develop a thorough understanding of the socio-political contexts surrounding engineering design and development. Without the in situ perspectives it will be difficult for students to fully develop an understanding of their ability to become change agents in this arena.

This paper presents findings from a pilot study on student perceptions of inequities in societal infrastructure systems conducted as part of an NSF-funded grant implementing cultural and curricular changes in a medium-sized civil engineering department in the southeast. Drawing on frameworks that examine how individuals critically understand systems of oppression, and the

justification used to explain these systems, our work is guided by the following research questions: (1) Are undergraduate civil engineering students critically aware of inequities in society's infrastructure systems? (2) To what degree are undergraduate civil engineering students comfortable challenging the status quo? (3) Is there an association between students' critical awareness of inequitable infrastructure systems and their agency to promote systemic change as civil engineering professionals?

Background Literature and Theoretical Framework

The present study draws on four frameworks to explore undergraduate civil engineering students' perceptions of infrastructure inequity in the United States, and their beliefs about whether they, as future civil engineers, might be able to bring about systemic change in support of equitable access and outcomes for all members of society. Critical consciousness, system justification, and social empathy are frameworks that can help aid us in understanding how civil engineering undergraduates perceive issues related to infrastructure inequity. Sociopolitical control is a framework that can provide insight into civil engineering undergraduates' beliefs that they can influence infrastructure policy decisions and hold leadership roles as professional civil engineers. Ultimately, the assessment of civil engineering undergraduates' perceptions of infrastructure inequities through these frameworks will provide the insight needed to enhance our understanding of their perceptions and values about stakeholder experiences within the context of infrastructure decisions, as well as their agency beliefs to combat inequities in this context. Each framework is further described in the following sections.

Critical Consciousness

Grounded in the pedagogical practices of Brazilian educator-philosopher Paulo Freire (1921-1997), critical consciousness comprises three components: (1) critical reflection, which is the critical analysis of inequitable social conditions; (2) critical motivation, which is the interest and agency one has to redress such inequities; and (3) critical action, which is the action taken to produce or participate in activities aimed at promoting societal change [3]-[6]. The likelihood of civil engineering undergraduates having influence on societal infrastructure as professional engineers is high, therefore, it is important that they are able to critically analyze systemic inequities related to infrastructure systems. Providing space to critically analyze these systemic inequities during training as undergraduates has the potential to develop future civil engineer's critical motivation to promote change and spur them to participate in activities that correct inequities.

System Justification Theory

System justification, first studied by Jost and Banaji in 1994, is the act of legitimizing, and therefore sustaining social arrangements even at the expense of personal and collective interests [7]. While individuals may not agree with every aspect of a system, or think that it is fair and just, they often hold favorable attitudes towards the system than they would through more critical examination [8]. While system-justifying beliefs vary, people within all levels of our social hierarchy engage in system justification [8], [9]. Understanding system justification beliefs among civil engineering students can provide insight for educators on course materials and activities that can promote students' understanding of and questioning of the status quo.

Social Empathy

Social Empathy is one's capacity to understand and respond to the experiences of people who identify with groups that are currently facing--or have historically faced--marginalization, oppression, or barriers that limit complete and self-determined engagement in society [10]. Social empathy not only comprises the components of interpersonal empathy (understanding of individual experiences) such as affective response, affective mentalizing, self-other awareness, perspective-taking, and emotion regulation, but also entails the broader intake of information on a macro level, through contextual understanding of systemic barriers and macro self-other awareness/perspective taking [11], [12]. Often unconscious, affective response (AR) is the reaction to an outside stimulus such as a sound or image [11], [12], [13]. Affective mentalizing (AM) is the cognitive process of evaluating someone's emotional state [11], [15]. Self-other awareness (SOA) is the capacity to identify with another person, especially with regard to their experiences and feelings, while maintaining one's sense of self [11]. Perspective-taking (PT) is the process of intentionally adopting the perspective of another person, for example "walking a mile in another's shoes" [11], [13]. Emotion regulation (ER) is the ability to "react to another's experiences and process what those reactions might mean without becoming overwhelmed or swept up into someone else's emotions" [11, p. 34]. These five components of interpersonal empathy serve as the foundation for social empathy, and lead to the final two components: contextual understanding of systemic barriers (CU) and macro self-other awareness/perspective taking (MSP). CU is the process of understanding and analyzing the sociohistorical contexts of groups different from our own [11]. MSP involves "walking in another person's shoes" with an understanding and awareness of the external factors shaping that persons' experiences, especially experiences leading to marginalization [11]. Developing and practicing social empathy can lead to improved interactions and outcomes between groups, and it can also potentially lead to systemic change. Because civil engineering students have the capacity as professional civil engineers to influence infrastructure systems, it is important to understand levels of social empathy within this population.

Sociopolitical Control

Sociopolitical Control has been traditionally conceptualized as comprising two dimensions: *leadership competence* and *policy control* [16], [17]. Leadership competence encompasses one's beliefs about their skills for organizing and leading groups and policy control is a person's belief they can influence decisions about policy in an organization or community [16]. Understanding civil engineering undergraduate students' sociopolitical control beliefs may provide insight about their agency to participate in activities that promote systemic change related to infrastructure inequities.

Methods

Participants and Procedures

Study data for this project included survey responses to validated scales measuring: critical consciousness, system justification beliefs, social empathy, and sociopolitical control beliefs. Participants were junior and senior undergraduate civil engineering students (n = 21; 57% women/43% men) enrolled in a professional development, community, and strategic change course offered within the department. The course was not required in the curriculum, thus students participated in this course in preparation to volunteer in a mentoring program for

incoming sophomores. Participants ranged in age from 20 to 25 (M_{age} = 21.6, SD = 1.2). Participants identified predominantly as White (76.2%), with 4.8% identifying as Black or African American, 9.5% identifying as Asian, and 9.5% identifying as Multiracial. Data was collected during the Fall 2020 semester using an online survey platform *Qualtrics*, with survey links posted in the online course management system.

Measures

Critical Consciousness

Critical Consciousness was measured using the Short Critical Consciousness Scale (CCS-S), a validated 14-item instrument measuring all three dimensions of critical consciousness [18]. In parallel with the original CCS [19], the CCS-S measures critical reflection's two sub-components: (1) perceived inequality and (2) egalitarianism. In addition to the CCS-S items, we administered eight additional items related to critical reflection, motivation, and action oriented toward inequities in infrastructure and civil engineering. Data for each dimension of critical consciousness was analyzed separately, in accord with original scale design features [18], [19].

Critical Reflection: perceived inequality

The CCS-S scale measuring *critical reflection: perceived inequality* (CR:PI) consists of three items that assess awareness of inequity across ethnic-racial, class, and gender lines. Items were answered on a 6-point Likert-type scale (1=*Strongly Disagree*, 6=*Strongly Agree*). An average score across items was calculated, with higher scores reflecting higher levels of critical reflection: perceived inequality (M = 4.67, SD = 1.04). A sample item for the CCS-S critical reflection: perceived inequality scale is "Certain racial or ethnic groups have fewer chances to get ahead."

Three adapted items were included to measure critical reflection about and awareness of infrastructure inequity. Items were similarly answered on a 6-point Likert-type scale (1=*Strongly Disagree*, 6=*Strongly Agree*) and an average score across items was calculated, with higher scores reflecting higher levels of critical reflection: perceived infrastructure inequality (CR:PI Infrastructure) (M = 4.37, SD = 0.86). A sample item for CR:PI Infrastructure is "Certain racial or ethnic groups have less access to modern, efficient, and reliable infrastructure."

Critical Reflection: egalitarianism

The original scale for *critical reflection: egalitarianism* (CR:E) consisted of three items that measure beliefs about group equality. Items were answered on a 6-point Likert-type scale (1=*Strongly Disagree*, 6=*Strongly Agree*). An average score across items was calculated, with higher scores reflecting higher levels of CR:E (M = 5.52, SD = 0.62). A sample item is "It would be good if groups could be equal."

Two adapted items were included to measure beliefs about infrastructure equality (CR:E Infrastructure). As with the other critical reflection: egalitarian measure, items were answered on a 6-point Likert-type scale (1=*Strongly Disagree*, 6=*Strongly Agree*). An average score across items was calculated, with higher scores reflecting higher levels of CR:E Infrastructure (M = 5.73, SD = 0.38). A sample item is "It would be good if groups had equal access to modern, efficient, and reliable infrastructure."

Critical Motivation

The CCS-S measure for critical motivation (CM) consisted of four items assessing commitment to and interest in bringing about change to society, in order to correct racial, social, and economic inequities. Items were answered on a 6-point Likert-type scale (1=*Strongly Disagree*, 6=*Strongly Agree*). An average score across items was calculated, with higher scores reflecting higher levels of CM (M = 5.44, SD = 0.55). A sample item is "It is important to correct social and economic inequality." One additional item was included related to motivation to address infrastructure inequities (CM: Infrastructure) (M = 5.5, SD = 0.69). This item was "As a civil engineer, it is important to use projects I am involved in to make things better for society and address society's most important issues through my work."

Critical Action

The CCS-S measure for critical action (CA) consisted of four items assessing the frequency of participation in activities geared to promote positive social change and correct inequities across ethnic-racial, gender, and social class lines. Items were answered on a 5-point Likert-type scale (1= *Never Did This*, 5= *At Least Once a Week*). An average score across items was calculated, with higher scores reflecting higher levels of CA (M = 1.50, SD = 0.54). A sample item is "In the last year, how often have you participated in a civil rights group or organization."

Two items were adapted and included to measure frequency of participation in activities to promote the rectification of infrastructure inequities (CA: Infrastructure). An average score across these two items was calculated, with higher scores reflecting higher levels of CA: Infrastructure (M = 2.23, SD = 1.10). A sample item is "In the last year, how often have you employed ethics and equity when working on projects or thinking about issues related to society's infrastructure."

Social Empathy Index

Social Empathy was measured using the Social Empathy Index (SEI), which assesses empathy on a macro level [11]. The SEI consists of 40 items that measure the seven dimensions of social empathy [11]. All items were answered on a 6-point Likert-type scale (1= *Never,* 6= *Always*). Average scores within each component were calculated, with higher scores reflecting higher levels of social empathy along each of its dimensions. Five items measured affective response (Social Empathy: AR) (M = 4.66*,* SD =0.86). A sample item is "When I see someone receive a gift that makes them happy, I feel happy myself". Four items measured affective mentalizing (Social Empathy: AM) (M = 3.98*,* SD = 0.38). A sample item is "I am good at understanding other people's emotions." Four items measured self-other awareness (Social Empathy: SOA) (M = 4.16*,* SD = 0.65). A sample item is "I can tell the difference between someone else's feelings and my own." Five items measured perspective-taking (PT) (M = 4.39*,* SD = 0.69). A sample item is "I can imagine what the character is feeling in a good movie." Four items measured emotion regulation (Social Empathy: ER) (M = 4.06*,* SD=0.87). A sample item is "Emotional stability describes me well." Nine items measured contextual understanding of systemic barriers (Social Empathy: CU) (M = 5.05*,* SD = 0.74). A sample item is "I believe that people who face discrimination have added stress that negatively impacts their lives." Lastly, nine items measured macro self-other awareness/perspective taking (Social Empathy: MSP) (M = 5.03*,* SD = 0.52). A sample item is "I can best understand people who are different from me by learning from them directly."

System Justification Scale

System Justification was measured using the System Justification Scale [20]. Ten items measured perceptions of fairness, legitimacy, and justifiability of the sociopolitical and economic system in the United States. Items were answered on a 6-point Likert-scale (1= *Strongly disagree*, 6= *Strongly agree*). An average score of item responses was calculated with higher scores reflecting higher levels of system justification (M = 3.08, SD = 1.11). A sample item is "America is the land of opportunity where everyone who works hard can get ahead."

Sociopolitical Control

Sociopolitical Control beliefs were measured using an adapted version of the Sociopolitical Control Scale (SPC) [16], [17]. This 17-item scale includes two subscales: *leadership competence* and *policy control*. Items for both subscales were answered on a 6-point Likert-type scale (1=*Never*, 6=*Always*) An average score of item responses was calculated for each subscale, with higher scores reflecting higher levels of leadership competence (SPC: Leadership) and policy control (SPC: Policy Control). The leadership competence subscale included eight items (M = 4.01, SD = 0.45). A sample item is "I am often a leader in groups." The seven items assessing policy control were adapted to reference "infrastructure" (as opposed to "community" or "school"), consistent with previous adaptations (M = 3.92, SD = 0.65) [16], [17], [21]. A sample item is "I enjoy participation because I want to have as much say in decisions about society's infrastructure as possible."

Results

Table 1 presents descriptive statistics for each construct of interest. On average, students agreed that certain groups had fewer chances to get ahead (CR: PI) and had less access to modern, efficient, and reliable infrastructure (CR: PI Infrastructure). Additionally, on average students agreed that groups should be equal (CR: E) and have equal access to modern, efficient, and reliable infrastructure (CR: E Infrastructure). Students also, on average, showed interest in bringing about change to society, in order to correct racial, social, and economic inequities (CA), as well as felt that civil engineers should use civil engineering projects to make things better for society as a whole (CA: Infrastructure).

Mean levels of CR:E were higher than CR:PI and CM. Consistent with prior work [22], CA levels were lower than other dimensions of critical consciousness, with students having low participation in activities promoting both positive social change and the rectification of infrastructure inequities. On average, students reported social empathy levels above the midpoint of the scale, with mean levels of contextual understanding and macro self-other awareness and perspective taking being the highest, and the mean levels of affective mentalizing being the lowest. Students generally reported that they somewhat disagreed that the sociopolitical and economic systems in the United States are fair, legitimate, and justifiable. Lastly, on average, students reported moderate levels of leadership competence and policy control related to infrastructure.

Table 1.
Descriptive statistics of variables

Variables	N	Mean	*SD*	Variance	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Std. Error
CR: PI	20	4.667	1.043	1.088	-1.340	0.512	2.472	0.992
CR: PI Infrastructure	20	4.367	0.858	0.736	-0.617	0.512	1.204	0.992
CR: E	20	5.517	0.616	0.380	-1.365	0.512	0.836	0.992
CR: E Infrastructure	20	5.725	0.380	0.144	-1.017	0.512	-0.371	0.992
CM	20	5.438	0.549	0.302	-1.101	0.512	1.004	0.992
CM: Infrastructure	20	5.500	0.688	0.474	-1.076	0.512	0.083	0.992
CA	20	1.500	0.544	0.296	0.885	0.512	-0.313	0.992
CA: Infrastructure	20	2.225	1.106	1.223	0.982	0.512	0.566	0.992
Social Empathy: AR	20	4.660	0.859	0.737	-0.694	0.512	0.116	0.992
Social Empathy: AM	20	3.975	0.380	0.144	-1.017	0.512	1.260	0.992
Social Empathy: SOA	20	4.163	0.650	0.423	0.089	0.512	-1.245	0.992
Social Empathy: PT	20	4.388	0.691	0.477	0.040	0.512	-0.875	0.992
Social Empathy: ER	20	4.063	0.869	0.756	0.535	0.512	-0.456	0.992
Social Empathy: CU	20	5.050	0.737	0.543	-0.581	0.512	0.134	0.992
Social Empathy: MSP	20	5.033	0.519	0.269	0.116	0.512	-0.933	0.992
System Justification	20	3.080	1.112	1.237	0.487	0.512	-1.130	0.992
SPC: Leadership	20	4.011	0.450	0.203	0.162	0.512	-0.390	0.992
SPC: Policy Control	20	3.919	0.650	0.423	0.022	0.512	-1.086	0.992

Note: CR:PI = Critical Reflection: perceived inequality; CR:PI Infrastructure = Critical Reflection: perceived inequality infrastructure; CR:E = Critical Reflection: egalitarianism; CR:E Infrastructure = Critical Reflection: egalitarianism infrastructure; CM = Critical Motivation; CM: Infrastructure = Critical Motivation Infrastructure; CA= Critical Action; CA: Infrastructure = Critical Action Infrastructure; Social Empathy: AR = Social Empathy Affective Response; Social Empathy: AM = Social Empathy Affective mentalizing; Social Empathy: SOA = Social Empathy Self-other awareness; Social Empathy: PT = Social Empathy Perspective Taking; Social Empathy: ER: Social Empathy Emotion regulation; Social Empathy: CU = Social Empathy Contextual Understanding; Social Empathy: MSP = Social Empathy: Macro self-other awareness/perspective taking; SPC: Leadership = Sociopolitical control: leadership competence; SPC: Policy Control = Sociopolitical control: infrastructure policy control beliefs

Table 2 presents bivariate correlations between study constructs. Of note, students scoring higher on CR:PI tended to have higher scores on CR:PI Infrastructure ($r = 0.76$, $p < 0.01$), suggesting the more critically aware students are of perceived inequality, the more likely they were to be critically aware of perceived inequality specifically related to infrastructure. Students scoring higher on CM tended to have higher scores on CR:E Infrastructure ($r = 0.54$, $p < 0.05$), whereas students scoring higher on CM: Infrastructure tended to score higher on CR:E ($r = 0.48$, $p < 0.05$). Additionally, there was a moderate, positive relationship between CA and CM ($r = 0.46$, $p < 0.05$), as well as a moderate, positive relationship between CA: Infrastructure and CR:E ($r = 0.54$, $p < 0.05$). There was also a moderate, positive relationship between CA: Infrastructure and CM: Infrastructure ($r = 0.54$, $p < 0.05$). This suggests that the more critically motivated students are to bring about positive social and infrastructure changes, the more likely they will be to participate in activities that bring about these changes. Further, it is likely that students who have

positive egalitarian beliefs are more likely to participate in activities that correct infrastructure inequities.

There was a moderate, positive relationship between Social Empathy: AR and CM: Infrastructure ($r = 0.55$, $p < 0.05$), suggesting an association between students' levels of affective response and their interest in bringing about positive changes to infrastructure systems. Additionally, there was a moderate positive relationship between Social Empathy: AM and CR: EG Infrastructure ($r = 0.64$, $p < 0.01$), suggesting that students who are more likely to practice behaviors of affective mentalizing may be more likely to have egalitarian beliefs related to infrastructure systems.

As expected, there was a strong, positive relationship between Social Empathy: PT and Social Empathy: SOA ($r = 0.73$, $p < 0.01$). Social Empathy: ER shared significant positive relationships with Social Empathy: AM ($r = 0.54$, $p < 0.05$) and Social Empathy: AM ($r = 0.50$, $p < 0.05$). Notably, Social Empathy: CU was positively associated with CR:PI ($r = 0.68$, $p < 0.01$), CR:PI Infrastructure ($r = 0.55$, $p < 0.05$), and CR: EG Infrastructure ($r = 0.55$, $p < 0.01$), suggesting that contextual understanding and analysis of the social history and experiences of groups different from our own may be related to critical reflection of social and infrastructure inequities. Likewise, Social Empathy: MSP had significant, positive associations with CR: EG ($r = 0.48$, $p < 0.05$) and CR: EG Infrastructure ($r = 0.57$, $p < 0.05$). Further, as expected, Social Empathy: MSP was positively associated with Social Empathy: AM ($r = 0.58$, $p < 0.01$), Social Empathy: ER ($r = 0.50$, $p < 0.05$), and Social Empathy: CU ($r = 0.46$, $p < 0.05$).

Of note, there was a moderate, negative correlation between system justification beliefs and CR:PI Infrastructure ($r = -0.56$, $p < 0.05$), suggesting that the more critically aware of infrastructure inequities students are the less likely they are to have system justifying beliefs. Contrary to expectations, there was no association between students' critical awareness of inequitable infrastructure systems and their agency beliefs to promote systemic change related to these systems. However, as expected, there was a strong positive association between SPC: Leadership and SPC: Policy Control ($r = 0.72$, $p < 0.01$).

Table #2.
Bivariate Correlations of Constructs

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. CR-PI	-																	
2. CR-PI Infrastructure	**.758****	-																
3. CR-EG	-0.082	0.098	-															
4. CR:EG Infrastructure	0.199	0.137	0.264	-														
5.CM	0.344	0.424	0.269	**.544***	-													
6. CM: Infrastructure	-0.318	-0.119	**.476***	0.252	0.087	-												
7. CA	0.201	0.376	-0.157	0.223	**.462***	0.141	-											
8. CA: Infrastructure	0.000	0.121	**.541***	0.155	0.219	**.536***	0.372	-										
9. Social Empathy-AR	-0.176	-0.219	0.394	0.236	-0.270	**.547***	-0.170	0.332	-									
10. Social Empathy-AM	0.376	0.148	0.037	**.642****	0.332	0.048	0.118	0.096	0.110	-								
11. Social Empathy-SOA	-0.021	-0.115	-0.213	0.318	0.073	-0.133	0.200	0.051	0.015	0.297	-							
12. Social Empathy- PT	-0.295	-0.229	-0.202	-0.134	-0.224	-0.011	0.286	0.340	0.076	-0.015	**.732****	-						
13. Social Empathy-ER	0.136	0.135	0.194	0.454	0.121	0.314	0.256	0.404	0.394	**.541***	**.497***	0.423	-					
14. Social Empathy-CU	**.684****	**.552***	0.048	**.554***	0.257	-0.334	0.241	-0.113	-0.066	0.397	0.278	-0.033	0.155	-				
15. Social Empathy- MSP	0.391	0.192	**.482***	**.567***	0.339	0.197	-0.022	0.156	0.295	**.576****	0.234	-0.193	**.489***	**.460***	-			
16. System Justification	-0.370	**-.558***	-0.148	-0.438	**-.560***	0.302	-0.422	0.027	0.178	-0.303	-0.087	0.034	-0.181	**-.729****	-0.251	-		
17. SPC Leadership	-0.122	-0.139	-0.101	-0.021	-0.016	0.229	-0.112	0.070	-0.024	-0.161	0.053	0.042	-0.196	-0.396	-0.138	0.420	-	
18. SPC – Policy Control	-0.294	-0.061	0.222	0.024	0.127	0.334	0.062	0.294	-0.011	-0.215	0.217	0.090	-0.077	-0.207	0.096	0.264	**.720****	-

**. Correlation is significant at the 0.01 level (2-tailed;. *. Correlation is significant at the 0.05 level (2-tailed).

Discussion

As societal relations and needs continue to evolve, it is important for future civil engineers to be critically aware of the social justice issues related to infrastructure systems. Understanding our students' perceptions of these inequities can help educators and curriculum developers modify their curricula to include greater emphasis on ethics and equity issues to provide our students with the tools to critically evaluate these inequities and correct them as professionals. Framed by theories that provide lenses for understanding systemic equities and fostering agency to correct these inequities, our pilot study explored undergraduate civil engineering students' perceptions of equity-related perceptions and beliefs about civil engineering and infrastructure systems by piloting new instrumentation. Descriptive statistics indicate that individuals in our sample had generally high awareness of societal inequities, egalitarian beliefs, and motivation to address inequities--both in general and in terms of infrastructure issues germane to civil engineering, in particular. Contrarily, individuals in our sample had lower levels of critical action or action specifically targeting infrastructure issues. These patterns of higher critical reflection and motivation and lower critical action parallel much of the literature in this area (for a review, see [23]; see also, for a recent example, [24]).

However, bivariate correlations did not support an association between students' critical consciousness and their agency beliefs that they can correct inequities as future civil engineers. This was somewhat surprising, given our expectation that those with higher levels of critical consciousness--especially in terms of its reflection or motivation dimensions--would have elevated levels of agency to participate in activities that may bring about change related to infrastructure inequities. Additional research bringing together critical reflection, critical

motivation, critical action, and sociopolitical control may verify the distinct, unrelated nature of these constructs or might suggest that a more nuanced set of relations exist. In other words, given that our work was somewhat exploratory in this study, future work should continue to interrogate for whom and under what conditions dimensions of critical consciousness--related to infrastructure or more generally--relate to sociopolitical control.

Limitations and Future Directions

Our study examined associations between undergraduate civil engineering students' critical consciousness, system justification beliefs, social empathy, and sociopolitical control beliefs. While results show notable relations among constructs of interest, our study is not without limitations. While this study was designed as a preliminary pilot study, the small sample size of the study constrained our ability to examine relations among study constructs in a more extensive manner; that is, we were limited to descriptive and correlational analyses. Future studies should consider building on this preliminary research by collecting data with a larger--and ideally more diverse--sample. This would allow for more fine-grained and nuanced analyses of the extent to which study constructs were associated across a more heterogeneous population.

Moreover, based on the sampling approach utilized, students in our study may have been predisposed to exhibiting critical consciousness, social empathy, or other social-justice related characteristics, especially given that our study was conducted within the context of a non-required course in which students were enrolled to become mentors of other undergraduate civil engineering students.

This work also developed new instrumentation to complement extant measures of critical consciousness. Specifically, items were developed to assess undergraduate civil engineering students' perceptions and awareness of inequities related to infrastructure and their interest and motivation to promote change and redress such inequities. To further validate the measures comprised by this new instrumentation, the items we developed should be administered with a larger sample and should be subjected to further empirical analyses, in order to better understand the ways in which they converge or diverge with extant measures. For example, CR: PI Infrastructure items could be analyzed alongside CR: PI items through the use of exploratory or confirmatory factor analysis in order to determine if the new infrastructure items do indeed comprise their own distinct construct or if instead, they might measure the same common factor as the other perceived inequality items.

Conclusion

This small-scale pilot study aimed to provide insight into whether undergraduate civil engineering students are critically aware of inequities in society's infrastructure systems, to identify the extent to which those students are comfortable challenging the status quo, and to examine the associations between students' critical awareness of inequitable infrastructure systems and their agency to promote systemic change as civil engineering professionals. We determined through this work that some aspects of critical consciousness are indeed related to particular views about infrastructure inequities. Those who endorsed egalitarian views, broadly speaking, appeared to be more motivated to address infrastructure inequities, and those who appeared most motivated to address infrastructure inequities appeared most committed to

actually take action to promote equity in terms of infrastructure-related issues. This pilot study lays the groundwork for and suggests the importance of continued work to understand and support undergraduate civil engineering students' understanding of and commitment to promote social change, justice, and equity through their work.

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