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Civil Engineering Students' Views on Infrastructure in the U.S.

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Introduction

Infrastructure is critical to society and drives the economic growth and well-being of communities. In the United States, decades of underinvestment have led to a deterioration of the infrastructure and the need for extensive maintenance and renovation [1]. To meet this challenge, a need exists to produce civil and environmental engineers who have a broad understanding of the pressing needs of U.S. infrastructure and who can think innovatively to rectify infrastructure deficiencies [2]. Effectively educating students requires that educators have an understanding of students' views and attitudes about infrastructure.

The need to better educate students about infrastructure led to the creation of the Center for Infrastructure Transformation and Education (CIT-E). CIT-E has developed connections between faculty from 30 institutions across the U.S. and Canada who are seeking to improve infrastructure education [3]. As part of the evaluation of the NSF-funded CIT-E project, researchers developed and implemented a survey of students' views of infrastructure. In this study, survey findings were used to address the following research questions:

1. What are civil engineering students' views on:
   a. The most and least important infrastructure components?
   b. Impact of infrastructure revitalization on their future careers?
   c. Current condition of the infrastructure?
   d. Willingness to consider non-traditional solutions to infrastructure challenges?

2. Are there regional differences in students' views of infrastructure (comparing students in the Northeast, Southeast, Midwest, Southwest, and West)?

3. Are there gender differences in students' views of infrastructure?

4. How do students' views of infrastructure change as they progress through civil engineering curricula?

Research Methods

The CIT-E management team developed the Infrastructure Views Survey (IVS) to assess the impact of infrastructure education, with the goal of determining students':

1. Understanding of the importance of infrastructure to society,
2. Appreciation of the infrastructure problems in the US,
3. Understanding of the potential solutions to infrastructure problems, and

4. Interest in infrastructure challenges and solutions, including the pertinence of infrastructure management to their future careers.

The IVS was developed in 2015 by engineering educators and the Psychology Department at Southern Utah University (SUU). Face validity was established through a review of the survey by faculty members who have taught the introduction to infrastructure course. The survey was piloted with a group of senior engineering students at the University of Utah. Researchers revised the survey based on pilot findings and conducted a second pilot with students at SUU after which the survey was finalized [4].

The final version of the IVS contains a combination of 47 rating scale, Likert-scale and open-ended responses (see Appendix A for the survey). Respondents provide their own definition of infrastructure and then are asked to rate the importance on a 10-point scale, from 1= *not at all* important to 10 = *extremely important,* of 22 components of infrastructure in five sectors. Sectors include

- transportation systems (roads, bridges, non-motorized travel, public transit, rail lines, aviation),
- built environment (dams, drinking water, sewage and wastewater, solid waste, public schools, colleges and univerisities, prisons/jails),
- natural environment (public parks and recreation areas, energy systems, agriculture),
- government agencies and systems (income taxes, law enforcement, postal service), and
- social systems (accessible medical care, social security, unemployment insurance, welfare assistance).

The survey also includes a series of questions asking respondents to assign a letter grade of A through F to various infrastructure components after first indicating their level of familiarity with the American Society for Civil Engineering (ASCE) Report Card for America's Infrastructure. Instructions included a descriptor for each letter grade: F = *Failing*, D = *Poor*, C = *Mediocre*, B = *Good*, and A = *Exceptional*. Students also had the option to choose *Don't Know*. For each item, respondents hovered over the term to see a defintion of that component so that all were working from the same definition. For example, when students were asked to rate the importance of levees or to assign a grade, they hovered over the word "levee" to see the following definition: "Man-made structures along the edge of rivers to control flooding."

Respondents also indicate their level of agreement (ranging from 1=*strongly disagree* to 5=*strongly agree*) with items about the importance of infrastructure challenges and solutions to their future careers. Several concluding items on the survey ask respondents to indicate their willingness to fund infrastructure projects through fuel taxes, paying more for peak electricity usage, and tolls for road repair.

For this paper, we present exploratory findings from the presurvey administered at the start of the semester. Presurvey findings help us to understand the attitudes and views that students have about infrastructure as they enter introductory infrastructure courses.

Survey Sample

Researchers made the IVS available to instructors in the CIT-E community beginning in the fall 2015 semester. For this paper, we present exploratory findings from the presurvey for a purposeful sample of 373 students across nine institutions between the fall 2015 and spring 2017 semesters. Courses in which the survey was distributed were taught by faculty members participating in the CIT-E project. Faculty members could elect to voluntarily participate in the survey. Institutional Review Board approval was obtained at each institution prior to administering the survey.

Instituitions participating in the survey varied in size and geographic location. Table 1 presents the institutions, course description and number of students responding from each institution. For seven of the courses surveyed, the class was a full semester on infrastructure topics. The other two courses were not a full semester of infrastructure education, but contained sections of the course devoted to an introduction to infrastructure components:

- "Engineering in the 21st Century" (University A) is a liberal studies course open to non-engineering majors
- "Introduction to Civil and Environmental Engineering" (University I) contained a unit in the course on infrastructure components.

The vast majority of respondents were engineering students. Only the "Engineering in the 21st Century" course at University A had non-engineering students (engineering students were also enrolled in the course).

Table 1. Characteristics of Participating Institutions and Numbers of Students Surveyed

Institution	**Region of US***	**Fall 2016 Undergraduate Enrollment**	**Course Title**	**Number Surveyed**
University A	West	8,407	Engineering in the 21st Century	16
University B	Northeast	3,152	Land Development and Infra-structure Engineering	61
University C	Northeast	14,345	Introduction to Infrastructure	139
University D	Midwest	7,861	Introduction to Infrastructure	58
University E	West	4,610	Introduction to Infrastructure	43
University F	Southwest	1,569	Introduction to Infrastructure	12
University G	Southwest	14,630	Introduction to Infrastructure	13
University H	Southeast	1,713	Introduction to Infrastructure	15
University I	Northeast	4,288	Introduction to Civil and Envi-ronmental Engineering	16
			Total Responses	**373**

*U.S. Census Bureau classification

The survey was administered in courses for civil and environmental engineering students, with the exception of the previously noted liberal study course at University A. The majority of survey respondents were male. Table 2 presents demographics for students completing the survey.

Survey Administration

Survey Gizmo, an online survey platform, was used for creating the survey. Researchers sent a link to the survey to participating faculty members for distribution to their students. To protect anonymity, students created a four-digit ID code that they entered on the survey so that researchers could match pre- and post-surveys for future analyses. Instructors shared the purpose of the survey—to inform educators' understanding of students' views of infrastructure and not as a part of their grade in the course. Use of a nonidentifiable ID allowed students to respond honestly to the survey. Administering the survey via a link made completion easy for students. Some instructors used class time to allow students to complete the surveys. Researchers provided instructors with updates on response rates and provided reminders to complete the survey to increase response rates.

Table 2. Demographics of Survey Respondents

Characteristics	N	Percent
Academic level		
Freshman	144	38.6
Sophomore	137	36.7
Junior	49	13.1
Senior	43	11.5
Gender		
Male	288	77.2
Female	84	22.5
No Response	1	0.3

Data Analysis

To address the research questions, researchers conducted descriptive analyses of survey findings including the mean of importance ratings for each infrastructure component and an overall mean for each sector and mean ratings of letter grade assigned to each infrastructure sector from the ASCE Report Card. Researchers conducted between subjects one-way analyses of variance (ANOVA) to compare importance ratings by region. Researchers also conducted independent samples *t*-tests to examine whether males and females differed in their infrastructure importance ratings and to examine whether students of differing academic levels held differing views.

Results of the survey reveal students' views coming into an introductory course on infrastructure and include: the importance of infrastructure components, how students perceive the importance of infrastructure to their future careers, how they perceive the current condition of infrastructure and, their willingness to consider non-traditional solutions to infrastructure challenges faced by the U.S. Findings also include regional, gender and academic level differences in students' views.

Students Views of the Importance of Infrastructure Components

Mean ratings of infrastructure components revealed that students entered classes attaching a high degree of importance to infrastructure systems and programs. All mean ratings were above the midpoint on the 10-point scale. Within the sectors, students rated infrastructure components related to the built environment (dams, drinking water, wastewater, solid waste disposal and schools) as the most important infrastructure sector (overall component M=8.80) and social programs (social security, welfare assistance, unemployment insurance and accessible medical care) as lowest (overall component M=7.11). The components "Government Agencies" and "Social Programs" may not be traditionally associated with infrastructure, particularly from an engineering perspective. However, these two components are needed in a functioning economy, thus satisfying the most general definition of infrastructure: the services and facilities necessary for a country's economy to function [5]. Inclusion of these components in the survey also sheds light on students' attitudes regarding the built environment as compared to non-built aspects of infrastructure. Figure 1 presents overall means for importance ratings of the five overarching infrastructure sectors in the survey.

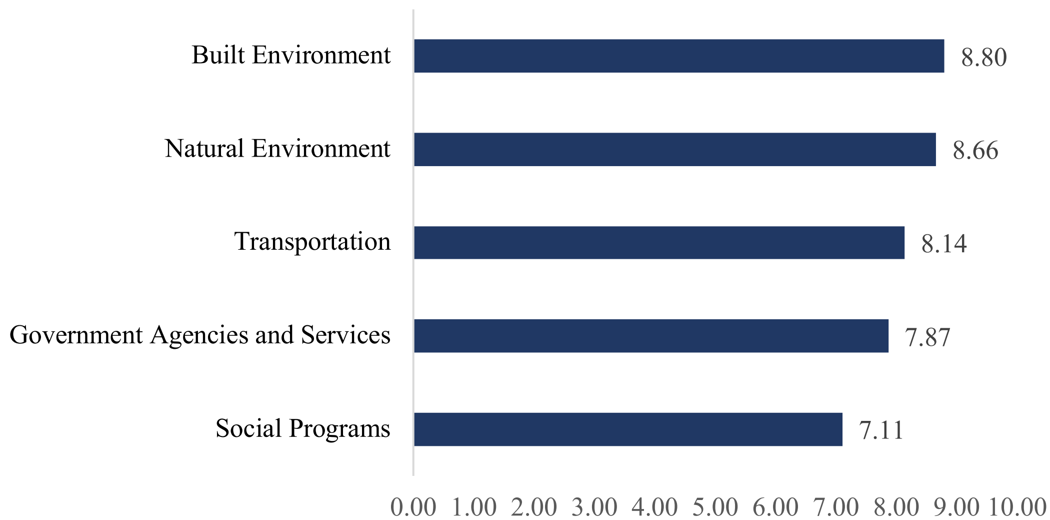

Figure 1. Overall mean ratings for infrastructure sectors (n=373).

More detailed findings related to student views on the importance of infrastructure are presented in the following sections. Table 3 gives mean importance ratings for each component within the sectors.

The Built Environment

Within the built environment, students rated the importance of all components as 7.67 or higher. They rated drinking water facilities highest in importance, and prisons and jails as the lowest. The mean importance rating for drinking water, M= 9.85 was the highest rating across all infrastructure components included in the survey.

The Natural Environment
Within infrastructure systems related to the natural environment, students rated the importance of energy and agriculture as 9.30 and 9.07 respectively. They rated recreation areas lowest with a mean rating of 7.62.

Transportation
Within the transportation sector, students rated the importance of all components as 6.87 or higher. Students rated roads as the most important component and nonmotorized transportation (bike lanes, sidewalks, etc.) as least important.

Government Agencies and Systems
Within the sector related to government agencies and systems, students rated the importance of all components at 7.49 or higher. They rated law enforcement highest and the postal service lowest in importance.

Social Systems
Social systems were the lowest rated sector in terms of importance. Students rated accessible medical care as the highest component of this system and welfare assistance as the lowest. Welfare assistance was rated the lowest component across all systems, however the mean rating for this system was still above the midpoint of the scale.

Table 3. Mean ratings of the importance of infrastructure components related to the five sectors of infrastructure (n=373).

Built Environment (Sector Mean = 8.80)			
Component	**Range**	**Mean**	**SD**
Drinking Water Facilities	5–10	9.85	0.59
Sewage Treatment	2–10	9.39	1.04
Public Schools	1–10	8.98	1.30
Solid Waste Disposal	2–10	8.97	1.36
Public Colleges	1–10	8.69	1.54
Dams	2–10	8.14	1.69
Prisons and Jails	1–10	7.60	1.99
Natural Environment (Sector Mean – 8.66)			
Component	**Range**	**Mean**	**SD**
Energy	4–10	9.30	1.13
Agriculture	1–10	9.07	1.38
Recreation Areas	1–10	7.62	1.92
Transportation (Sector Mean = 8.14)			
Component	**Range**	**Mean**	**SD**
Roads	5–10	9.48	0.91
Aviation	1–10	8.60	1.61
Public Transit	1–10	7.96	1.75
Rail Lines	2–10	7.81	1.83
Nonmotorized Transportation	1–10	6.87	2.01

Government Agencies & Services (Sector Mean = 7.87)			
Component	**Range**	**Mean**	**SD**
Law Enforcement	3–10	8.58	1.41
Income Taxes	1–10	7.55	1.84
Postal Service	1–10	7.49	1.96
Social Systems (Sector Mean = 7.11)			
Component	**Range**	**Mean**	**SD**
Accessible Medical Care	1–10	8.05	2.03
Social Security	1–10	7.40	2.12
Unemployment Insurance	1–10	6.66	2.24
Welfare Assistance	1–10	6.34	2.43

Students' Perceptions of the Current Condition of U.S. Infrastructure

To understand students' perceptions of how well the U.S. is doing with respect to maintaining its infrastructure, students assigned a letter grade to the 16 infrastructure categories graded each year by the American Society for Civil Engineers (ASCE) in their Report Card for America's Infrastructure. Students taking the survey were asked to choose a grade for each from among the responses shown in Table 4.

Table 4. Grade scale for infrastructure components and GPA points used to determine average ratings.

Response	GPA Points
A = Exceptional	**4**
B = Good	**3**
C = Mediocre	**2**
D = Poor	**1**
F = Failing	**0**
Don't Know	**(not included)**

Student responses were used to create an "average rating" for each component using the "GPA Points" shown in Table 4 (e.g., a weighted average was calculated with each "A" response assigned 4 points, "B" responses assigned 3 points, etc.). "Don't Know" responses were included in Table 5 to understand the levels of awareness of each category, but responses of "Don't Know" were not counted in the average rating. A letter grade was assigned to each "average rating" using the following scale:

3.86 – 4.00 A	3.16 – 3.50 B+	2.16 – 2.50 C+	1.16 – 1.50 D+
3.50 – 3.85 A-	2.86 – 3.15 B	1.86 – 2.15 C	0.50 – 1.15 D
	2.50 – 2.85 B-	1.50 – 1.85 C-	0.00 – 0.50 F

In Table 5, each infrastructure component in ASCE's 2017 Report Card for America's Infrastructure is listed along with the grade assigned by ASCE, students' average ratings and the corresponding grade, and the number of students responding "Don't Know." Students' grades of the infrastructure components and the overall U.S. infrastructure were higher than the ASCE grades except for bridges and solid waste where they were the same as the ASCE grades and for rail where students actually graded lower. Civil Engineering students' perceptions of the health of the U.S. infrastructure indicates a misperception of the overall health of U.S. infrastructure components. This is indicative of the lack of understanding of infrastructure challenges by students early in their engineering careers that can be directly addressed through courses or lessons early in the Civil Engineering curriculum. Students may have limited interaction with many of the sectors of infrastructure, and greater understanding of the importance and challenges of those sectors can serve to strengthen their overall education and their abilities to address those challenges in their future careers. Future research comparing pre and post responses from the same student group will inform whether targeted education about infrastructure changes students' perceptions.

Table 5. Student "grades" for infrastructure components. The ASCE column shows the grade assigned in the 2017 Report Card for America's Infrastructure [1]. *"Avg Rating" is the average rating given by respondents on a four-point scale, "Grade" is the grade corresponding to the average, and "Don't Know" is the number of respondents selecting "Don't Know."*

	ASCE 2017 Report Card	**Student Ratings**		
		Avg.	**Grade**	**Don't Know**
Aviation	D	3.10	B+	13
Bridges	C+	2.37	C+	6
Dams	D	2.59	B	30
Drinking Water	D	2.81	B	8
Energy	D+	2.53	B	10
Hazardous Waste	D+	2.16	C+	52
Inland Waterways	D	2.48	C+	56
Levees	D	2.18	C+	87
Ports	C+	2.57	B	89
Public Parks & Recreation	D+	2.66	B	11
Rail	B	2.42	C+	18
Roads	D	2.13	C	3
Schools	D+	2.31	C+	2
Solid Waste	C+	2.35	C+	26
Transit	D-	2.34	C+	5
Wastewater	D+	2.41	C+	35
Overall GPA	D+	2.24	C+	

Comparing Geographic Regions on Grading U.S. Infrastructure

Researchers examined regional differences in students' grades of the overall U.S. infrastructure. Participating institutions included schools in the Northeast, Southeast, Midwest, West and Southwest. Figure 2 presents grades by geographic region.

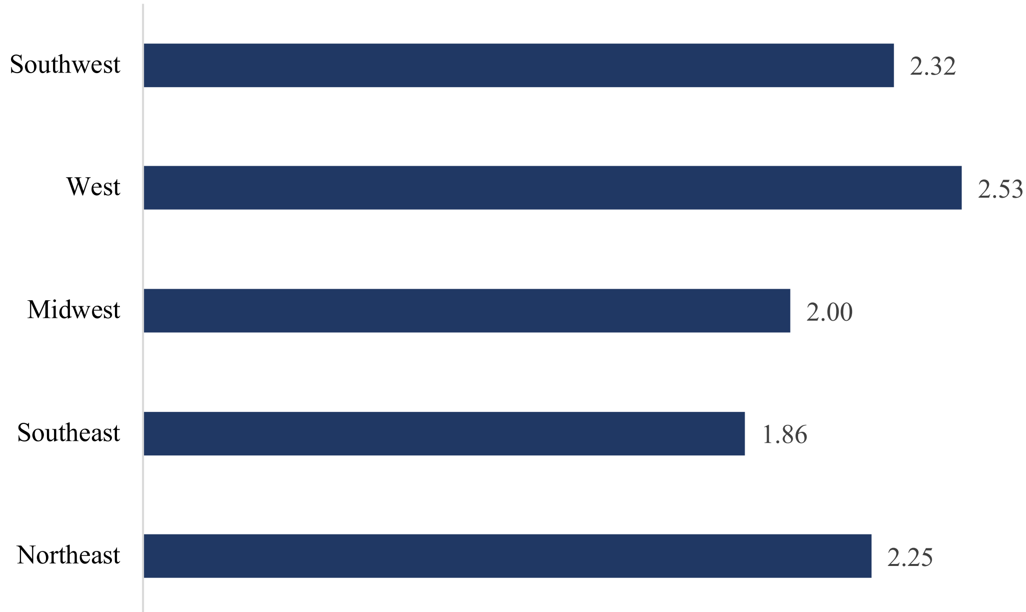

Figure 2. Average grades for U.S. infrastructure by geographic region (n=373).

To examine whether importance ratings varied by geographic region, researchers conducted one-way between groups analyses of variance to explore the impact of geographic location on students' grades for infrastructure. The southeast region was removed from these analyses due to a small sample size (n=15). There was a statistically significant difference at the $p < .05$ level in the grades students assigned to U.S. infrastructure overall: F (3, 351) = 4.25, $p = .006$. Post-hoc comparisons using the Tukey HSD test indicated that the mean grade for students in the West (M = 2.53, SD = 0.75) was significantly higher than for students in the Midwest (M = 2.00, SD = 0.80). Despite reaching statistical significance, the actual difference in mean scores was small. The effect size, calculated using η^2 was .03. Results should be interpreted with caution due to small sample sizes.

Students' Perceptions of the Impact of Infrastructure Revitalization on their Future Careers

The IVS poses the statement, "Infrastructure challenges and solutions will be important to my future career." Respondents can choose their level of agreement using a five-point Likert Scale: *Strongly disagree*, *Disagree*, *Neither agree nor disagree*, *Agree*, *Strongly agree*. Figure 3 shows how students responded to this question. The majority of students (82.5%) agreed or strongly agreed that infrastructure challenges and solutions will be important to their future careers. Only 3.4% of the students disagreed or neither agreed nor disagreed with the statement, but a much larger portion (13.9%) strongly disagreed.

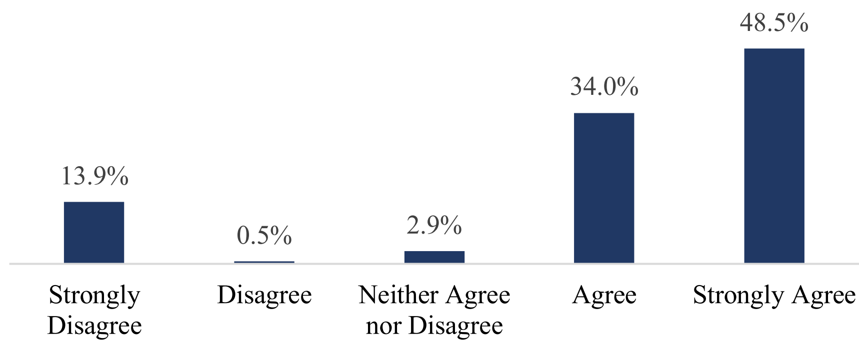

Figure 3. Responses to the statement, "Infrastructure challenges and solutions will be important to my future career (n=373*)."*

Students' Willingness to Consider Alternative Solutions to Infrastructure Challenges

The IVS poses questions about students' willingness to consider non-traditional solutions, such as mileage fees and peak demand pricing, to infrastructure challenges. Admittedly, students are more price-sensitive than the general population, so the fact that students may be unwilling to pay demand pricing for an infrastructure system does not necessarily mean they would not be willing to design such a system as professional engineers. Students' receptiveness to these non-traditional solutions are discussed below.

Individual Mileage Fees

Students were provided background information about fuel taxes with the following statements: "*Funding for roads and bridges generally comes from fuel taxes. Those who use more fuel generally pay more for maintenance and upkeep. However, newer cars using hybrid or electric power systems are using the same roads, but not paying as much in taxes."* They then responded to the following question, "How willing would you be to approve a system that pays for road and bridge maintenance using a mileage fee charged to each driver instead of a fuel tax?" Responses are on a five-point Likert Scale: from *Very unwilling*, *Unwilling*, *Neutral*, *Willing*, *Very Willing*. Figure 4 presents student responses. Of the students, 44.2% indicating a willingness to approve some system whereby individual drivers were charged a mileage fee.

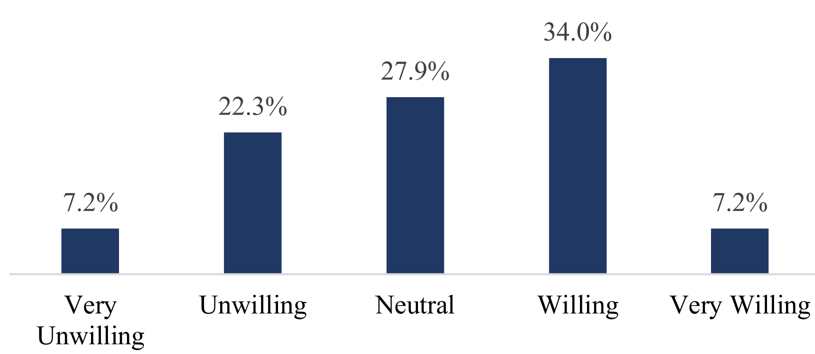

Figure 4. Responses to the statement, "How willing would you be to approve a system that pays for road and bridge maintenance using a mileage fee charged to each driver instead of a fuel tax?" (n=373*)*

Peak Electricity Costs
The IVS presents the following information: "*Most electrical utility companies charge people for the amount of power they use regardless of the time of day. However, peak use occurs when the grid is under heavy strain and electricity is more expensive. One potential solution is to charge more for electricity during peak usage times (like when the temperature is highest and more people are using air conditioning) and less during off-peak times.*" Students then responded to the Question, "How willing would you be to pay a higher rate for electricity during peak usage times?" Of the respondents, 31% indicated a willingness to pay more during peak times. Figure 5 presents students' responses.

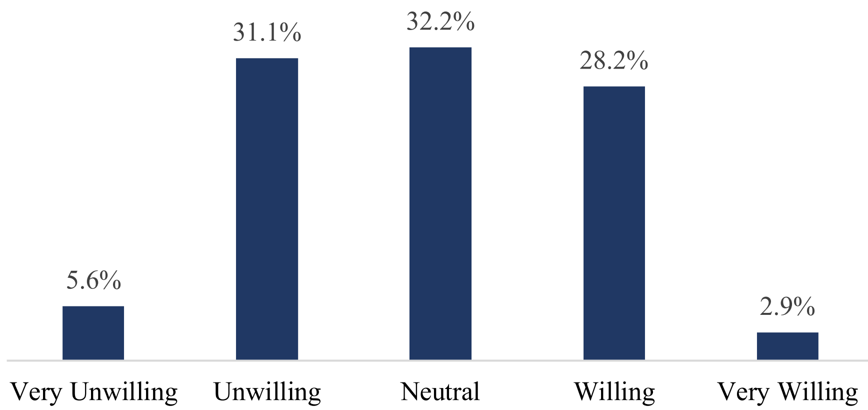

Figure 5. Responses to the statement, "How willing would you be to pay a higher rate for electricity during peak usage times?" (n=373)

Peak Traffic Tolls
Students also indicated their level of agreement with the statement, "I would be willing to pay an extra toll to drive on roads during peak traffic times if it meant less traffic." Figure 6 presents the responses to this item. Of the respondents, 42.9% were willing to pay an extra toll to reduce traffic.

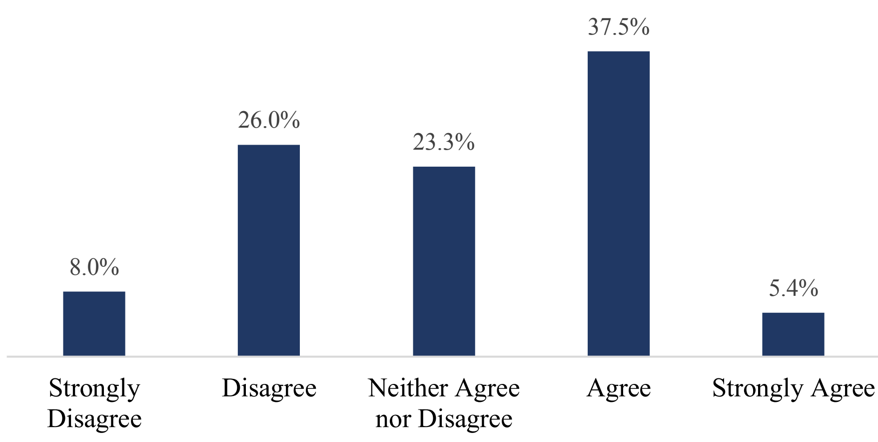

Figure 6. Responses to the statement, "I would be willing to pay an extra toll to drive on roads during peak traffic times if it meant less traffic." (n=373*)*

Comparing Geographic Regions in Rating the Importance of Infrastructure

Researchers examined regional differences between students' views of the importance of infrastructure components. Participating institutions included schools in the Northeast, Southeast, Midwest, West and Southwest. Figure 7 presents overall sector means by geographic region.

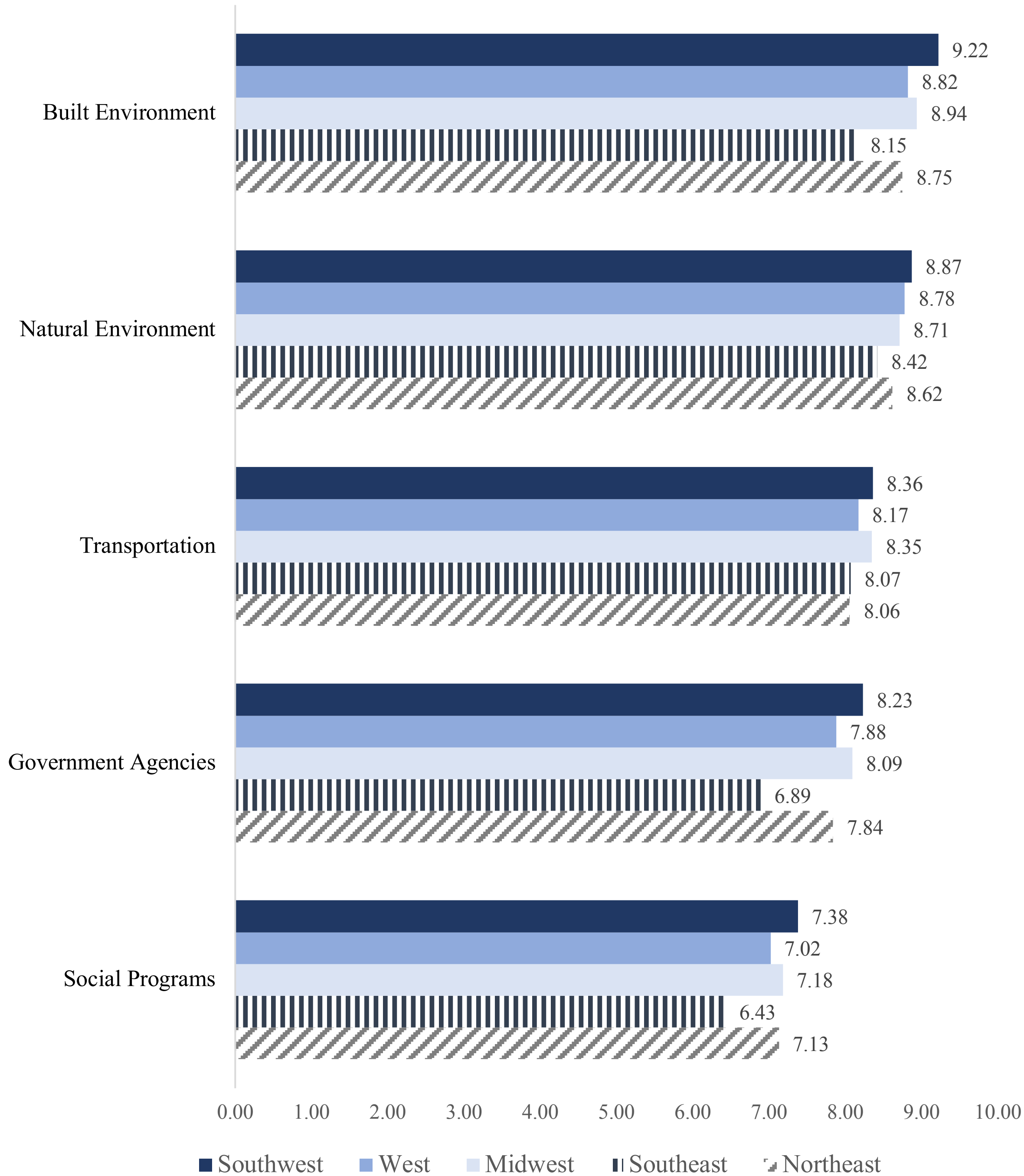

Figure 7. Overall mean ratings of the importance of infrastructure sectors by geographic region (n=373).

To examine whether importance ratings varied by geographic region, researchers conducted one-way between groups analyses of variance to explore the impact of location on value placed on infrastructure components. The southeast region was removed from these analyses due to a small sample size (n=15). Regional differences were not statistically significant for importance attached to the natural environment, transportation, government agencies, social programs or the built environment.

Researchers sought to determine if variation in regional focus on infrastructure projects and funding levels might explain the differences in student attitudes. Table 6 shows comparative rankings *at the state level* for the following indicators of infrastructure spending:

- Percent of bridges rated structurally deficient,
- Drinking water infrastructure spending needs, per capita,
- Percent of roads in poor condition, and
- Gap in school capital expenditures, per capita.

Lower ranking values indicate better performance on the infrastructure indicators (e.g., lower percent of structurally deficient bridges, etc.). State-level infrastructure data were obtained from the "Infrastructure Super Map" [6]. Per capita calculations use population data from the U.S. Census Bureau [7].

Table 6. Comparative rankings of funding indicators for infrastructure in the institutions' states

Institution	U.S. Region	Percent of structurally deficient bridges	Drinking water needs	Percent of roads in poor condition	Gap in school capital expenditures
University A	West	2	8	1	6
University B	Northeast	3	5	5	9
University C	Northeast	8	2	9	7
University D	Midwest	7	3	7	5
University E	West	4	9	3	3
University F	Southwest	5	4	6	8
University G	Southwest	1	6	2	1
University H	Southeast	6	1	4	4
University I	Northeast	9	7	8	2

Differences in infrastructure funding at the state level varied dramatically within regions. For example, in the southwest region University G was ranked first or second in all but one category, while the other southwest institution (University F) was ranked in the bottom half of all but one category. This variation within regions made it difficult to determine if regional infrastructure spending could explain differences in students' views in each region.

Comparing Males and Females in Rating the Importance of Infrastructure

Researchers examined whether males and females viewed the importance of infrastructure differently by conducting independent samples *t*-tests. Overall mean importance ratings by gender for infrastructure importance ratings are shown descriptively in Figure 8.

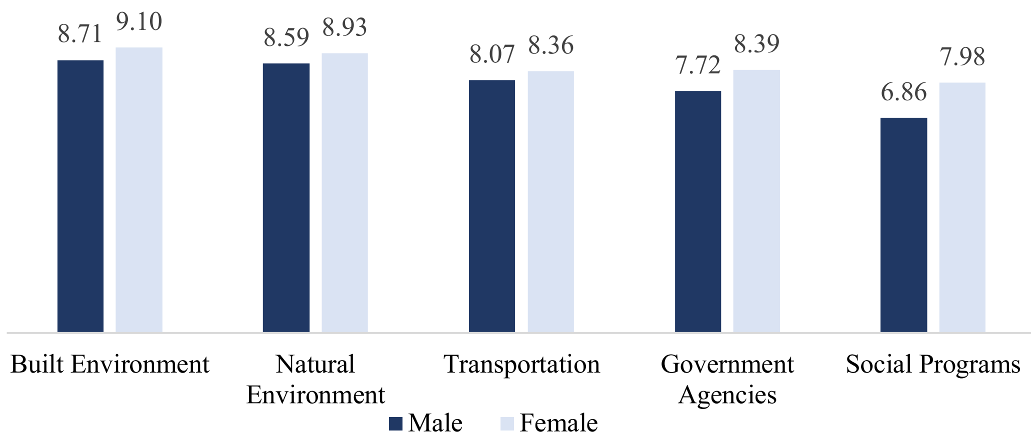

Figure 8. Overall mean ratings of the importance of infrastructure sectors by gender (n=372).

As shown in Figure 7, female students rated the importance of all infrastructure sectors higher than did males. Results of independent samples *t*-tests indicated the differences were significant (Table 7). The magnitude of the difference for each sector was large as measured by Cohen's *d*.

Table 7. Results of independent samples t-tests to examine gender differences in importance ratings of infrastructure sectors.

Sector	N	Mean	SD	Mean difference	*p*-value	*d*
Built Environment						
Female	84	9.10	0.79			
Male	288	8.71	0.96	0.38	.001	0.44
Natural Environment						
Female	84	8.93	1.00	0.34	.016	0.31
Male	288	8.59	1.17			
Transportation						
Female	84	8.36	1.14	0.29	.040	0.26
Male	288	8.07	1.12			
Government Agencies						
Female	84	8.39	1.10	0.67	<.001	0.52
Male	288	7.72	1.45			
Social Programs						
Female	84	7.98	1.59	1.12	<.001	0.64
Male	288	6.86	1.90			

Comparing Academic Levels in Rating the Importance of Infrastructure

Researchers examined whether underclassmen (freshmen and sophomores) viewed the importance of infrastructure differently from upperclassmen (juniors and seniors) by conducting independent samples *t*-tests. Overall mean importance ratings by academic level for infrastructure importance ratings are shown descriptively in Figure 9. Results of independent samples *t*-tests indicated the differences between academic levels were not significant (Table 8). The magnitude of the difference for each sector was small as measured by Cohen's *d*.

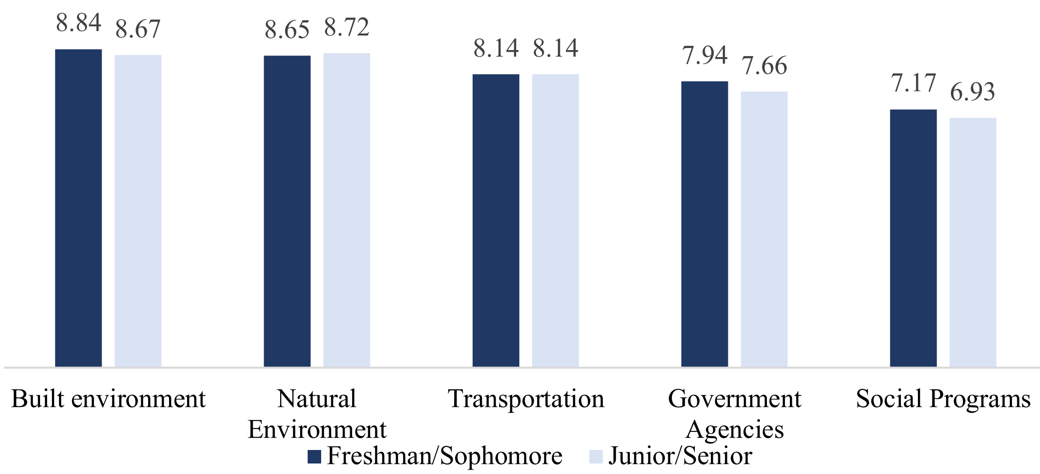

Figure 9. Overall mean ratings of the importance of infrastructure sectors by academic level (n=373).

Table 8. Results of independent samples t-tests to differences in importance ratings of infrastructure sectors by academic level.

Sector	N	Mean	SD	Mean difference	*p*-value	*d*
Built Environment						
Freshman/Sophomore	281	8.85	0.84	.18	.178	0.17
Junior/Senior	92	8.67	1.17			
Natural Environment						
Freshman/Sophomore	281	8.65	1.12	0.07	.059	0.06
Junior/Senior	92	8.72	1.18			
Transportation						
Freshman/Sophomore	281	8.14	1.10	0.002	.99	0.001
Junior/Senior	92	8.14	1.21			
Government Agencies						
Freshman/Sophomore	281	7.94	1.33	0.28	.094	0.18
Junior/Senior	92	7.66	1.61			
Social Programs						
Freshman/Sophomore	281	7.17	1.76	0.24	.34	0.11
Junior/Senior	92	6.93	2.23			

Discussion

In this study, researchers sought to provide insight into student perceptions of infrastructure before receiving in-depth exposure to infrastructure concepts. The intent is to help educators improve teaching effectiveness through a better understanding of their students' infrastructure views and attitudes.

At the start of infrastructure courses, civil engineering majors attached a high level of importance to infrastructure components. This may be reflective of their inherent interest in infrastructure as engineering students. Students' level of interest in infrastructure does not seem to be based on exposure to civil engineering concepts, since their views concerning level of importance were not dependent on their class standing (freshman/sophomore vs. junior/senior). While students rated the importance of infrastructure highly, the majority were not supportive of alternative options for increasing funding to support it when it came at personal expense.

While valuing infrastructure, students tended to assign higher grades to most components than ASCE at the start of introductory courses on infrastructure. Future research comparing results of students pre and post measures will serve to examine the effectiveness of infrastructure courses on bringing students' views of the condition of infrastructure into alignment with professional engineers.

Gender differences in views on infrastructure was the only variable that resulted in statistically significant results with a large magnitude. While this is an intriguing finding, the data provided by the survey and the smaller sample size of female students do not allow a non-speculative interpretation of these results.

Future Work

Findings from this study are preliminary and reflect a purposeful sample of students enrolled in courses where introductory infrastructure topics are taught and may not be generalizable to a larger population. A study encompassing a larger, more diverse set of educational institutions would be helpful in verifying that findings of this study accurately reflect civil engineering students' views. Such a study would also allow comparison of infrastructure views at the state level, which is important because infrastructure funding can be dramatically different between states within the same U.S. geographical region. A larger study would also help to verify the finding of a gender difference in student views of infrastructure. The larger study could collect more demographic data in order to determine other factors (such as students' preferred field within civil engineering, their engineering background, and their family background) to help better understand the results. Qualitative research methods (such as focus groups) could shed light on why gender differences might exist.

Further research using the IVS to assess *non-engineers*' views of infrastructure may be useful in understanding how the general public views infrastructure as compared to professional engineers and engineering students. Using the IVS to determine the views of policy makers might also help civil engineering professionals be able to better inform and persuade federal and state governments of the importance of infrastructure investment.

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