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First-Year Students' Incoming and Outgoing Conceptions of Equitable Infrastructure

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Abstract

This complete research paper explores how first-year students at four different institutions understood equitable infrastructure at the beginning and end of a first year, first-semester course in 2024. This paper compares and contrasts different models of teaching equitable infrastructure topics in these first-year courses and evaluates their impact on students.

While technical outcomes related to infrastructure, such as highway design or water system design, are taught most commonly in civil engineering programs, we all experience the built environment as users. Thus, the built environment – "infrastructure" – provides a jumping off point for all students, regardless of intended major, to begin developing a socio-technical perspective and understanding of the inequities that have been built into our engineered systems.

In all four courses, students completed a concept map activity focused on equitable infrastructure during the first week of class and again at the end of the term. These concept maps were analyzed using standard metrics of depth and connectivity, and they were compared using an evaluation rubric to identify the types of concepts that were expected to be included, based on definitions of equitable infrastructure that are commonly endorsed by professionals.

The paper offers insights into the efficacy of different approaches to integrating equitable infrastructure concepts into first-year courses, reflections on student outcomes, and suggestions for faculty to effectively and efficiently introduce students to these topics. Our goal in sharing this work is to inspire discussion within the engineering community about how faculty and departments across the U.S. can address equity and infrastructure in courses and curricula on their own campuses. The paper originally was submitted in January 2025. In revising, we have added an Appendix that discusses conditions in April 2025, which represent an abrupt change in national conditions related to DEIJ topics as compared to Fall 2024 when the teaching activities were conducted.

Introduction

Engineering programs continue to adapt to changing stakeholder demands for better integration of diversity, equity, inclusion, and justice (DEIJ) into both classrooms and curricula. For example, ABET's approved new Criterion 5 will require programs to offer curricula "that ensure[s] awareness of diversity, equity, and inclusion for professional practice consistent with the institution's mission" [1] (note that this webpage has since been removed). Integrating concepts related to equitable infrastructure provides an opportunity for programs to address this criterion through engaging, meaningful, and widely applicable learning activities. Historically, this type of extra-technical content was relegated to stand-alone senior-level ethics courses, but there is a trend towards bringing this content earlier in the engineering sequence. Introducing students to equity-focused engineering ideas in their first year can leverage incoming students' desires to change the world [2] and frame engineering as a sociotechnical discipline through which they can effect that change.

This study, which builds on a pilot study conducted by three of the authors [3] included four first-year engineering courses at different types of institutions. Three courses – with enrollments of 18, 18, and 29, respectively – focused on equitable infrastructure and included the term in some form in the course title. These institutions include a medium-size private university in the northwest, a small private liberal arts college in the mid-Atlantic, and a medium-size private university in the northeast. The fourth course focused generally on civil engineering and included equitable infrastructure within an array of topics aimed at introducing the discipline of civil engineering to first-year students. This course enrolled 53 students at a large, land-grant university in the mountain west. Enrollments in these courses included not only students intending to earn civil engineering degrees, but also students who saw themselves pursuing other majors within or outside of engineering.

In each course, students were given an assignment to create a concept map for the phrase "equitable infrastructure" during the first class meeting (pre- map) and again at the end of the term (post- map). In three of the courses, students reflected on similarities and differences between their initial and final maps. We examined the maps through standard concept mapping metrics as well as thematic coding. This paper describes the motivation for the work, the courses themselves, the concept-mapping activity, our analysis, and our conclusions. Appendix A discusses changes that occurred between January 15 and May 1, 2025 as a result of Executive Orders that have changed the context of initiatives that promote diversity, equity, inclusion, and justice (DEIJ) in higher education and in infrastructure delivery. In short, while changes to federal funding and attempts to shut down DEIJ initiatives are disruptive, the need for this work remains critical.

Background

The first canon of the NSPE Code of Ethics states that "Engineers, in the fulfillment of their professional duties, shall … Hold paramount the safety, health, and welfare of the public" [4]. This suggests that equitable engineering needs to be integrated throughout every engineering program. However, as faculty with civil and environmental engineering backgrounds we are particularly interested in the integration of equity within the content area of civil infrastructure. Civil infrastructure plays a fundamental role in helping to ameliorate or further exacerbate social inequities. To make more equitable decisions in how we plan, design, operate, and manage our infrastructure, engineers need to better understand the fundamental and ubiquitous role of infrastructure in society. At the same time, engineers need to better communicate to the public the technical and economic challenges and tradeoffs inherent in infrastructure decision-making. This interdependent learning - among communities and engineers - will result in a more complete understanding of the complexity of these interrelationships. Offering undergraduate courses that address equity and infrastructure to students of all majors is one way of beginning to bridge this gap.

First-year students often do not have a solid understanding of engineering and its different disciplines. Many students enter college without a clear direction, and others will change their majors; thus, exposing them to different types of engineering can be valuable as they determine the paths they want to follow. Some majors appear more human-focused than others (e.g.,

biomedical engineering) and may attract more equitably minded students. Further, interest in equity topics such as social justice has been found to be higher among female students and those from racial and ethnic backgrounds historically underrepresented in engineering [e.g. 5]. This self-selection is detrimental to efforts to diversify the engineering workforce across *all* disciplines, a necessity if engineering designs and products are to lead to more equitable sociotechnical outcomes.

In integrating equity into engineering education, equity concerns must not be presented as add-ons and secondary to technical considerations, but rather as important criteria and constraints for ethical engineering practice. It is also foundational to help engineering students recognize when current policies, practices, and structures perpetuate inequities and harms to particular groups of people. Building this mindset in future engineers will help avoid repeating historical issues where inequities were created and exacerbated.

Many institutions are adding more equity-focused content to first-year programs. Nonetheless, there remains a lack of research on the efficacy of the many different pedagogical approaches being used. By looking across four courses in four institutions that teach similar equitable infrastructure content in different ways, we hope to add new insights to the question of how best to teach equity-focused engineering to first year students.

Concept Maps

This study employs student-created concept maps to examine student learning within and between courses. Concept maps have been widely used both to foster learning and assess learning [6], [7]. In its simplest form, a concept map is a drawing that students use to explain a concept (in this case 'equitable infrastructure') based on other concepts that relate and contribute to it. Students add nodes or terms that clarify the central concept, along with links (lines or arrows) that show the relationships between the ideas. Concept maps can reveal students' conceptions and misconceptions about complex topics; for example, concept maps on sustainability have frequently been used in engineering education [e.g., 8-14]. A recent meta-analysis across 142 students found that concept maps facilitated student learning in STEM and non-STEM topics [15]. While simple counting methods are often used for scoring, these numbers of nodes, links, and hierarchy do not fully reflect the accuracy or complexity of the concept map. Thus, this study employs both standard quantitative scoring methods and thematic coding.

Course and Institutional Contexts

This study compares four courses taught in Fall 2024 at four different types of institutions. These institutions are: Lafayette College, Gonzaga University, Tufts University, and the University of Colorado Boulder. Table 1 summarizes basic characteristics of these courses and the level of integration of different equitable infrastructure topics.

Table 1: Overview of the four courses – equitable infrastructure teaching time and topics

	Lafayette College	Gonzaga University	Tufts University	U Colorado Boulder

Instructional time				
Contact hours per week	2 x 75 min	2 x 75 min	2 x 75 min	1 x 50 min
Percent and hours of course focused on Equitable Infrastructure	85% ~ 30 hr	70% ~ 32 hr	75% ~ 25 hr	12% ~2 hr
Topics				
Infrastructure types & design				
Urban Planning				
Differential impacts by race, SES, language, ability, etc.				
Climate resiliency / sustainability				
Environmental justice				
Redlining / highway siting				
Disability in design				
Economic and Health Outcome Inequality				
Information Literacy				
Justice 40				
Future World Vision				
Impact of Policy & Regulations				

Shading degree represents how frequently and in what depth the topic was discussed in the course. Darkest shading: topic was a major focus; medium shading: topic was in multiple classes; lightest shading: topic was touched on; white (unshaded): topic was not mentioned.

At Lafayette College, a small, private liberal arts college in the mid-Atlantic region, all first-semester students are required to complete a first-year seminar (FYS). FYS courses are taught by faculty and staff members from all disciplines at the institution, each of whom designs a course to engage students in common outcomes related to college-level reading, writing, and thinking around a topic of the professor's choice. In addition to the common outcomes, each instructor designs topic-specific learning outcomes. These outcomes for the section studied here, "Sustainable Cities: Urban Infrastructure and Equity," are that students will be able to: 1) Explain how infrastructure affects their own lives and the lives of others in their home community on a daily basis, and 2) Analyze the differential equity and justice impacts of infrastructure on a community with regard to health, employment, wealth, etc. Student topic preferences are considered in course enrollment; as a result, most FYS sections consist of students with a variety of intended majors. Of the 18 students enrolled in this FYS section, ten indicated an intention to major in engineering, two of whom identified civil engineering

specifically. Other potential majors identified included economics, environmental science, film and media studies, government and law, and mathematics. Seven of the students (39%) identified as female two (11%) were students of color.

The 1-credit course met for two 75-minute class sessions per week and also for lunchtime guest speakers and other out-of-class activities (all 1-credit courses at Institution A are equivalent to 4-credit courses under typical semester credit hour counting). Students completed substantial reading and writing assignments both inside and outside of class, and classes were largely discussion-based. Reading and writing centered around four primary assignments: a reflection on "What is a city?," an infrastructure biography (in which students reflected on how a particular type of infrastructure has affected their lives), an infrastructure walk (in which students presented their observations and reflections on a 1-mile walk in our local community), and an investigation and reflection on impacts of redlining on infrastructure today in a selected city.

Gonzaga University, a medium-sized, private liberal arts university in the Pacific northwest, requires all first-semester students to complete a first-year seminar course (FYS). Each FYS has common learning outcomes: 1) differentiate how knowledge is created across different disciplines, 2) articulate how the student's perspectives affect their discovery and generation of knowledge, and 3) integrate how Gonzaga's mission relates to the student's own academic, personal, and spiritual aspirations. The course discussed in this paper was an FYS entitled "Equity and Infrastructure." The 18 students enrolled in the course were engineering (including mechanical, civil, and electrical) and computer science majors who were also part of a Learning and Living Community (LLC), which involved dorm rooms in the same residence hall and a one a month optional out of class activity like volunteering for Habitat for Humanity or learning design for 3-D printing. Two of the 18 students (11%) were female. In addition to the aforementioned FYS learning objectives, this course also had an optional social justice core designation with additional learning outcomes of 1) describe how social systems affect people, 2) understand and articulate how are attitudes and behaviors shaped by biases, 3) articulate the ethics behind working toward common good, and 4) demonstrate commitment to the need for working toward a more just world.

The 3-credit course met twice a week in a seminar style and focused on active learning activities, field trips, guest speakers, and small group discussions. Substantial readings and reflective writing assignments outside of class were required. The course used interstate highways as a case study to explore how infrastructure impacts society from both historical and modern perspectives. For the second half of the semester, students were tasked with developing a case study on a topic of their choice and presenting their findings to the class. Because of the mix of engineering and computer science majors, the case studies used a broad definition of infrastructure so that they could all find topics related to their interests including Artificial Intelligence and Large Language Models.

At Tufts University, a medium-sized private university in the northeast, all first-semester engineering students (and students who intend to transfer into engineering) take one of 19 themed sections of the introductory "Applications in Engineering" course. Every section emphasizes project work, engineering ethics, and the engineering design process. The section included in this study was titled "Equitable and Inclusive Civil Infrastructure." About a third of

the 29 enrolled students stated they chose to enroll in this section because of the focus. At the beginning of the semester, 11 students were considering a major in civil and environmental engineering. Twelve of the 29 students (41%) were women, lower than the engineering freshman class average of 51%.

The 3-credit course met twice a week for 75 minutes, with most class meetings featuring a short introductory lecture followed by a small group activity. Classes also included a field trip, guest speakers, and small-group project working sessions. The course centered around four areas of civil infrastructure: water, waste, transportation, and energy, with a "technical" homework assigned for each area. A case study of inequitable infrastructure for each area took a full class period; these focused on Warren County, NC (waste), Flint, MI (water), racial implications of interstate highway siting across the U.S. (transportation), and community solar programs (energy – note this was an example of equitable infrastructure). The majority of the course grade came from three projects: developing a case study of inequitable infrastructure from the past or present, a concrete lab report that included discussions on material sustainability, and a final group project of a case study of a current or future restorative justice or sustainability-focused infrastructure effort.

The University of Colorado Boulder, a large public research-intensive university in the West, requires students majoring in civil engineering are to take the 1-credit introduction to civil engineering course. In addition, a number of students in the College of Engineering are admitted as undeclared engineering majors and choose to explore civil engineering by enrolling in the course. In Fall 2024, about half of the students enrolled in the course were declared majors in civil engineering and the other half were exploring different engineering majors. The total enrollment at the end of the semester was 53 students (34% female). The course met for one 50-minute session each week of the semester. The main goal of the course was to introduce students to the profession of civil engineering, including sub-specialty areas (e.g., structures, geotechnical, construction, transportation, water resources, environmental), ethics, and sustainability. In most weeks there was an in-class lecture on a topic (e.g., ethics), students were assigned a reading and/or online video, and they wrote a 250-500 word response to questions. The focal activity in the course was a team-based bridge design project. It required students to use software to design bridges optimized to balance deflection (safety), cost, and environmental impacts (including a calculation of the carbon footprint from the concrete and steel in the bridge) situated in one of 5 assigned scenarios from the American Society of Civil Engineers' (ASCE) Future World Vision [16]. Within the teams, students compared their individual bridge designs using a weighted decision matrix; the teams then presented their selected bridges to the class and wrote a team-based report that included reflections on ethics and sustainability issues.

Equitable infrastructure was not a focus in the course, but it relates to the learning objectives of ethics and sustainability. During the week that addressed diversity, equity, and inclusion, a guest speaker spoke about resilient infrastructure with sustainability and equity, largely in the context of natural disasters. For the weekly homework assignment (see Appendix B), students chose two from among nine resources (readings, videos, the MegaCity 2070 app, or the Climate and Economic Justice Screening Tool (CEJST)) [17].

Research Questions

We sought to answer the following research questions:

RQ1. What similarities and differences were found among the concept maps of equitable infrastructure created by first-year students in courses at four different institutions?

RQ2. What changes across the semester were found in the concept maps of first-year students who were enrolled in courses that taught about equitable infrastructure in various ways?

RQ3. What did students notice when comparing their pre- and post- concept maps?

Methods

This research included courses at four institutions, conducted under an approved protocol for human subjects research (Lafayette College IRB AY2425-11).

Shared Concept Map Activity

At all four institutions, students completed a concept-mapping activity by hand on the first day of class and again at the end of the term; the prompt is shown in Figure 1. In addition to the prompt, students were provided with written and oral instruction on how to construct a concept map. Students had varying levels of prior experience in creating concept maps and spent different amounts of time creating these; some followed instructions more carefully than others (across all institutions). All students completed the activities whether or not they gave consent for the maps to be used; only the maps of those students who consented (94% for Lafayette, 100% for Gonzaga, 97% for Tufts, and 75% for Colorado) were analyzed for this study. Further, at two of the Institutions (Lafayette and Tufts), students wrote short reflections comparing their initial and final maps. Students earned small amounts of course credit toward the course grade for completing the mapping and reflection exercises; there was no grade incentive to construct larger/more intricate maps or to be sure to mention particular concepts.

Quantitative Concept Map Metrics

Concept maps for each institution were scored quantitatively by counting the number of nodes, links, highest hierarchy, and total words and then calculating the cross links and overall score. If a link included an arrow head on both ends (indicating two-way interactions), this was counted as two links. The number of cross-links (CL) was calculated as the number of links minus the number of nodes. The highest hierarchy (HH) on each map also was counted, representing the "depth" of a single chain of ideas on the map. Finally, a total score was calculated (nodes + 5 HH + 10 CL). In addition, the total number of words that were part of each map was tallied. This included words in the concepts (some students used one-word concepts in each node whereas others had a more extensive description) and words on the links. Note that these results include *all* maps for which students provided consent and that, for a variety of reasons, the total number of initial maps (101) is larger than the total number of final maps (83). For some maps, students did not include a root node labeled "Equitable Infrastructure," and many students used lines rather than arrows to connect nodes. In some cases, this led to uncertainty about whether a link

should be counted as a one- or two- way link; it also made it difficult or impossible to determine the highest hierarchy for some of the maps.

Your task is to develop a concept map for "Equitable Infrastructure" (i.e., a map that in visual terms answers the question, "What is equitable infrastructure?")

- Brainstorm for a few minutes and, on this or another sheet of paper, write down terms and short phrases that are connected to your current understanding of equitable infrastructure.
- On a *new* sheet of paper, draw a concept map based on your brainstorming, placing "Equitable Infrastructure" at the center or top of the drawing and drawing lines to other related concepts.
- After you have sketched in the primary associations, move on to add secondary or tertiary levels of association (or more), if appropriate.
- Determine the ways in which the various concepts are related to each other and write those types of relations on the lines connecting the concepts.

Figure 1. Concept Map Activity Prompt

Coding of Concept Map Themes

Common concepts were observed among the maps, and we used emergent coding methods to analyze these themes. Each concept map was coded "1" if any of the terms associated with a theme were used. If that theme was not identified in the map it was coded as "0".

We further analyzed concept map themes for the students who completed both the pre- and post-maps and determined the differences between the paired maps. When comparing the pre and post maps, a -1 was assigned if the theme was on the pre- concept map but not the post-. A zero was assigned if there was not a change in value, so either absent from both maps or present on both maps, and a +1 was assigned if the topic was found on the post- map but not the pre- map.

Holistic Characterization of Concept Maps

Each concept map also was characterized holistically by two of the authors (the instructor for that course and one other author) based on the primary concept shown in the map, such as infrastructure, equity/social, or sustainability. If maps had more than one area represented among these major areas, they were classified as balanced. For maps where the two initial reviews differed, another author conducted a third review to reconcile the differences.

Student Reflection

At Lafayette College, Gonzaga University, and Tufts University, students were given their pre-concept maps back at the end of the semester; at the University of Colorado Boulder, students reflected in writing on the semester as a whole. Students at Lafayette and Tufts were asked further to compare the two maps in about one double-spaced page, including what was similar and different, and why. These responses were not formally coded, but the instructors have noted trends and particularly interesting responses.

Results

Quantitative Metrics

Table 2 summarizes the concept map pre- and post- metrics for all maps at each institution, including the numbers of nodes and cross links, highest hierarchy, overall score, and total number of words. Comparatively, the initial maps from Tufts University had the highest average overall score (meaning they were the most sophisticated structurally) while the end-of-term maps from Lafayette College had the highest average overall scores. Generally, maps at all institutions saw increases in all metrics between the pre- and post- mapping activities. The exception was Tufts, where maps showed slight decreases in two measures (number of cross links and overall score); it should be noted, however, that Tufts had the highest pre- concept map metrics. Standard deviations are large for all measures and for all institutions. For every institution, the number of nodes in the maps increased from pre- to post-, reflecting students identifying more concepts at the end of the semester than at the beginning. Students at every institution also wrote more words on their end-of-term maps than on their initial maps. While these results seem to reflect increased sophistication and development of concepts in student thinking, we note that these quantitative metrics do not necessarily reflect directly the *quality* of the concepts and words written. Nonetheless, review by the researchers shows that the predominance of the additional nodes and words were, in fact, relevant to the topic.

Qualitative Coding

Table 3 shows the percentage of maps at each institution and at all institutions that had each theme present. Bold text indicates overarching themes such as Sustainability and Infrastructure, and shaded cells in the table highlight themes contained by the majority (50% or greater) of the maps. The themes with the highest average scores across all institutions are communities/cities (post-), cost/economic (pre- and post-), infrastructure (pre- and post-), and transportation (pre- and post-). For most themes, the percentage of maps containing the theme increased from the beginning to the end of the term. However, overall, the percentage of maps containing the themes environment, society/social, and jobs decreased. We hypothesize that students may have incorporated these ideas into other concepts or have considered them less important relative to other concepts by the end of the semester.

Appendix C includes examples of concept maps characterized as Balanced, Infrastructure, and Equity, as well as paired examples of pre- and post- maps where the focus changed.

For the paired pre-/post- analysis across all institutions, some of the largest net positive differences in students' concepts were found in the areas of cost/economics (+43), social justice (+27), transportation (+39), water (+26) and environment (+20). There were only a few themes where the pre-/post- differences were negative (that is, students included the concept in their initial map but not in the final map), including accessibility (-3) and pollution/contamination (-1). Note that these paired pre/post are not calculated using the values in Table 3 – Table 3 values are percentages of *every* pre- or *every* post- map, while some students were missing one or the other. The paired analysis instead compares each individual student's pre- and post- maps,

removing from the analysis any student who is missing one or the other. As a result, for example, while the percentage of maps containing the cost/economics theme decreased from pre- to post- in three of the four institutions, the overall percentage of maps containing the theme *increased* slightly, and the *number* of students who added that theme was comparatively large.

Table 2. Average, standard deviation, and range of quantitative concept map metrics

Institution	Nodes	Cross Links	Highest Hierarchy	Overall Score	Total Words
Lafayette Pre (n=17)	16±7 (5-29)	3±4 (0-14)	4±1 (3-7)	68±42 (25-196)	51±31 (20-155)
Lafayette Post (n=17)	31±14 (8-59)	5±5 (0-15)	6±2 (4-9)	111±58 (14-235)	64±29 (18-140)
Gonzaga Pre (n=18)	9±5 (3-22)	1±1 (0-7)	3±1 (1-5)	34±17 (9-64)	28±14 (9-57)
Gonzaga Post (n=17)	16±5 (10-26)	3±4 (0-12)	3±1 (2-5)	67±42 (22-166)	47±23 (17-93)
Tufts Pre (n=26)	16±6 (8-28)	5±5 (0-17)	6±1 (4-9)	93±52 (31-233)	41±14 (27-93)
Tufts Post (n=24)	24±12 (6-50)	4±4 (0-17)	6±2 (3-9)	91±52 (27-241)	65±35 (17-129)
Colorado Pre (n=40)	8±4 (3-17)	1±2 (0-5)	3±1 (1-7)	36±18 (9-72)	22±13 (5-53)
Colorado Post (n=25)	11±6 (5-27)	2±3 (0-11)	3±1 (1-6)	41±36 (0-154)	26±14 (8-59)

Holistic Characterization

The results of the holistic map characterization process, in which maps were described by their dominant overall characteristic, are shown in Table 4. The largest percentage of maps were classified as balanced, and the percentage increased from pre- to post-, possibly reflecting an increased understanding of the importance of multiple concepts behind the topic of equitable infrastructure. Further, on average across all institutions, the percentage of maps that were equity/social, sustainability, and policy focused increased, while the number that were heavily focused on the physical infrastructure decreased. There also was a reduction in the number of maps that were classified as other, indicating that more students were able by the end of the

course to identify at least one of the major themes. Changes in the classification of maps for the individual institutions reflect the different emphasis each course placed on the various topics.

Table 3. Percentage of the student concept maps at each institution that contained various themes

Theme	Examples		LC	GU	TU	CU	All
Sustainability	Sustainable, Sustainability	Pre	**29%**	**22%**	**4%**	**15%**	**16%**
		Post	**41%**	**29%**	**29%**	**48%**	**37%**
Environment	Environment, Greenhouse Gases,GHG, Emissions, Pollution, Environmental Impact Statements, Climate	Pre	18%	11%	58%	13%	25%
		Post	29%	6%	17%	20%	18%
Safety/Health	Safety, Health, Clean Water	Pre	12%	6%	19%	5%	10%
		Post	35%	24%	33%	40%	34%
Society/Social	Social, Society, People, Population, Human	Pre	6%	6%	23%	13%	24%
		Post	6%	18%	8%	29%	16%
Communities/ Cities	Cities, Citizens, Communities, Marginalized Communities	Pre	41%	17%	58%	18%	32%
		Post	41%	65%	29%	63%	48%
Cost/Economic	Cost, Economics, Economy, business/businesses, Funding, Money, Taxes, Pricing	Pre	59%	44%	62%	28%	45%
		Post	41%	41%	54%	50%	47%
Jobs	Jobs, workers, employment	Pre	29%	0%	4%	1%	6%
		Post	8%	0%	0%	0%	2%
Diversity	Diversity, DEI, Inclusion, Minority/ Minorities, Low Income, Race, Classes, Poor/Rich, Demographics, Disability/Ability	Pre	**53%**	**11%**	**27%**	**10%**	**22%**
		Post	**63%**	**65%**	**63%**	**8%**	**39%**
Accessibility	Accessibility, access	Pre	35%	39%	58%	39%	36%
		Post	47%	29%	71%	29%	37%
Social Justice	Social Justice, Equity, Inequity, Bias	Pre	6%	11%	23%	0%	9%
		Post	18%	53%	67%	4%	35%
Infrastructure	Infrastructure (any type)	Pre	**76%**	**44%**	**69%**	**40%**	**54%**
		Post	**53%**	**71%**	**75%**	**38%**	**58%**
Transportation	Transportation, Highways, Interstate, Buses, Public Transport Transit, Bridges, Trains	Pre	71%	39%	65%	28%	47%
		Post	59%	59%	67%	25%	51%

Theme	Examples		LC	GU	TU	CU	All
Water	Water, Pipes, Stormwater	Pre	53%	6%	42%	15%	28%
		Post	65%	18%	50%	17%	36%
Housing	Housing, Houses, Low Income Housing, Buildings	Pre	53%	6%	42%	15%	27%
		Post	65%	18%	50%	17%	36%
Energy	Energy, Power, Electrical/Electricity	Pre	47%	6%	27%	10%	20%
		Post	35%	18%	50%	13%	29%
Other Themes							
Policy/ Legislation	Policy, Laws, Legislation, Redlining, Justice40, Environmental Justice	Pre	12%	6%	4%	3%	5%
		Post	29%	24%	29%	0%	19%
Government	Government public/private ownership, political, politics	Pre	24%	0%	23%	0%	10%
		Post	29%	0%	25%	0%	13%

Table 4. Percentage of student concept maps classified by type

Map type	Lafayette		Gonzaga		Tufts		Colorado		All	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Balanced	65%	59%	17%	63%	52%	61%	13%	13%	32%	46%
Equity/Social	0%	0%	39%	31%	16%	30%	23%	25%	20%	23%
Infrastructure	29%	29%	28%	6%	20%	9%	23%	0%	24%	10%
Sustainability	0%	6%	0%	0%	8%	0%	30%	58%	14%	19%
Policy	6%	6%	0%	0%	0%	0%	0%	4%	1%	3%
Other	0%	0%	17%	0%	4%	0%	13%	0%	9%	0%

Student Reflection

During the last class of the semester at Lafayette College, students created a new concept map using the same prompt they had used on the first day of class. When they were finished, they received their original map back and were asked to compare the two in writing. Some students reflected on the concepts, while others provided more superficial comments about having the same number of main topics or similar organization. Of those who reflected more fully, many noted that their post-maps were more detailed and that they could see where they added concepts they had learned about in class. For example, one student wrote: “This time around, I was

thinking more about policies, programs, and rights based on certain personal demographics. … I also noticed that I referenced politicians and the role they play in supporting equitable infrastructure. … In my second map, I also made sure to include that equitable infrastructure should be indiscriminate and easily accessible for all citizens/members of any given community, city, county, and/or neighborhood." Another wrote "I believe that I failed to mention these issues on my map in the beginning of the course not because of a lack of knowledge on the subjects, but rather because of a lack of knowledge of how these things can affect communities. I had very little knowledge of the lasting effects of many of these infrastructure choices that seem so simple, but in reality shape communities everyday."

At Gonzaga University, the student concept maps from the first day of class wre returned to them while they were completing their second concept mapping exercise on the last day of class. The students were not asked to reflect on the differences between their maps, but the instructor plans to add this component to future classes. Several students mentioned during the second mapping exercise how much more they felt like they knew about the social impacts of technical decisions.

At Tufts Univesrity, many students already had a fairly strong understanding of equitable infrastructure before the class, as evidenced by the pre-maps. The pre- concept maps were quite detailed and included many concepts and connections–in fact, the overall score decreased slightly from pre- to post-. However, in their reflections comparing their own pre- and post-maps, students discussed how their maps showed that their thinking about equitable infrastructure had grown over the course of the semester. While the number of concepts and connections may not have changed or in some cases decreased, they noticed that, overall, the post- maps were more organized, included more specific language, and used more specific examples (Figure 2). Many students specifically stated that they included examples and topics they learned in class, which they were not aware of prior to class, including case studies of Flint, MI, indigenous-led dam removal projects, and community solar programs. A few students noticed that they included some concepts on their pre- maps that they did not include on their post- maps, which contained mostly topics covered in class. They had not noticed this shift until looking at both maps together, and they were surprised to see that concepts they were focused on before the class were now missing. For example, one student wrote, "My concept map from after the semester focused more on equitableness, and the one from the start of the semester focused more on environmental problems and consciousness. I think this was because in this class we focused a lot on inclusiveness in infrastructure and less on environment."

At the University of Colorado Boulder, the students did not have their first concept maps returned and an opportunity to reflect on the differences. However, in the final term paper students discussed and reflected on the semester as a whole. Students were prompted to discuss what they learned about ethics and sustainability but not specifically DEI or equity. A quick word search of the final essays found that 17 of 53 mentioned equity. Even the small equitable infrastructure integration into the 1-credit course can impact students (Figure 3).

Discussion

The results above have provided substantial opportunity for reflection on our research questions:

RQ1. What similarities and differences were found among the concept maps of equitable infrastructure created by first-year students in courses at four different institutions?
RQ2. What changes across the semester were found in the concept maps of first-year students who were enrolled in courses that taught about equitable infrastructure in various ways?
RQ3. What did students notice when comparing their pre- and post- concept maps?

> Comparing my first and last-day concept maps, I see some obvious differences. The main difference is the terminology I used in the first and the second. In the first one, I focused on more of the direct causes and results of different aspects of infrastructure, like bridges or green space, and in the second, I referred to more of the basic infrastructure terms that I've grown more confident and familiar with over the semester, like renewable energy, landfills, fossil fuels, etc. Despite these differences, there are many similarities between the maps. They both feature many of the same buzzwords you associate with equitable infrastructure, like transportation, energy, and waste. This shows that even before the class started, I had a basic understanding of some of the topics and components that go into equitable infrastructure. Even still, the difference is now I have a better sense of what goes into infrastructure; I feel like I can talk about these topics more and understand what equitable infrastructure means in the context of things like waste management, transportation, energy management, and water. Overall, both my concept maps are very similar and both contain a lot of the same ideas, but the truth is that I've learned a lot in this class and equitable infrastructure.

Figure 2. Quote from Tufts University student reflection

> Before taking this class, the only ethical components I thought of when I considered civil engineering were very generic…. However, there was one specific learning activity in week 7 that made me realize that ethical considerations extended much deeper than my surface level knowledge. In this activity, we watched a video from the article, *Engineering More Equitable Communities*. In this video they discussed the topic of **systematic racism - something I was oblivious about**, but entails a pattern of repeatedly making decisions that cause a disadvantage towards a specific group of people. In the specific clip, an example of how it was implemented in civil engineering regarded highways - and how we used to build highways not for ultimate convenience, but in locations that would be re-homing Americans of color rather than white Americans …. This was a very bizarre idea to me …. not only was the process unethical, but it was also unsustainable.

Figure 3. Quote from University of Colorado Boulder student reflection

Students likely entered each of the classes with different levels of knowledge and/or interest in equity, infrastructure, and equitable infrastructure based on the title of the course and their major. Differences found on the pre- concept maps allude to these differences.

Overall, as we hoped, the results of the analysis show that the concept maps students created at the end of the term were richer and more topically relevant than those they created on the first day of class. As reflected in the standard deviations in Table 2, the initial and final concept maps themselves varied substantially both across and within institutions in terms of sophistication and how closely students followed the instructions. Across all institutions, students identified more

concepts, and more relevant concepts, in their end-of-term concept maps as compared to those they completed initially. Students across most institutions shifted toward more balanced maps, including more concepts related to both "equity" and "infrastructure." Most students, however, did not connect the concepts directly; rather, they created separate branches for concepts related to physical infrastructure and concepts related to equity. In keeping with the different emphases of the four courses, some concepts were more prevalent in the maps from some institutions.

At Gonzaga, this is the second time this course was taught; with the first course offering were primarily civil engineering majors, which led to a lower emphasis on types of infrastructure in the second offering. This change was very noticeable to the instructor in the final concept maps. The instructor also felt that the additional breadth of topics in the students' case studies increased the overall understanding of the broad impacts that the fields of engineering and computer science have on people.

With regard to concept map creation, we note that despite the instructions, the majority of students did not label the links on their concept maps, and some did not include the phrase "equitable infrastructure" as the root node. Many students also neglected to draw the links as arrows, so the direction of relationships sometimes was unclear. This is particularly challenging with cross-links since it was unclear if the student had an idea about one-way or two-way interactions. Further, depending on the directionality of the cross-links, some of the maps that were "webs" could have a somewhat infinite hierarchy number. Allocating more time to the activity, highlighting these features on example concept maps, and instructors circulating to help students follow the instructions as they work could all increase these dimensions of map quality.

Conclusions

This paper presents four different approaches to teaching first-year students about equitable infrastructure. In all approaches, students demonstrated through pre- and post- concept mapping activities that they grew in their understanding of how the built environment is foundational to an equitable society, furthering their understanding of sociotechnical thinking. Benefits of introducing students to a sociotechnical framework, and particularly to issues of equity in engineering practice, include the potential for recruiting and retaining a diverse student body and ultimately transforming engineering practice.

The pre- and post- concept mapping activity implemented at all four institutions provides a useful tool for assessing student knowledge in an authentic way. It provides instructors with snapshots of students' incoming and outgoing thinking in terms of concepts, relationships, and complexity. Providing clear instruction, sufficient time, and appropriate incentive for thoughtful engagement could improve the usefulness of the tool.

The four first-year courses studied differ in terms of institution type, course learning outcomes, and student contact hours. Based on our analysis, students improved their understanding of equitable infrastructure in all four courses. This reinforces our belief that there is no single "right" way to integrate issues of equity into engineering education. We hope that sharing this work inspires and helps others to develop their own initiatives leading to a more equitable future.

Acknowledgements

We are grateful to our students for their inspiration, their engagement with challenging and sometimes emotionally charged topics, and their willingness to participate in this study. We also are grateful for our colleagues across the U.S. who also are working to recontextualize civil engineering education and we appreciate their willingness to share ideas and resources.

References

[1] "Accreditation Changes - ABET," *ABET*, Dec. 18, 2023. https://www.abet.org/accreditation/accreditation-criteria/accreditation-changes/

[2] E. A. Cech, "Culture of Disengagement in Engineering Education?," *Science, Technology, & Human Values*, vol. 39, no. 1, pp. 42–72, Sep. 2013, doi: https://doi.org/10.1177/0162243913504305.

[3] K. L. Sanford, A. R. Bielefeldt, and R. K. Young, "Teaching First-year Students to See Infrastructure Issues as Equity Issues," in *2024 ASEE Annual Conference & Exposition*, Jun. 2024. Available: https://peer.asee.org/48062

[4] NSPE, "NSPE Code of Ethics for Engineers | National Society of Professional Engineers," *NSPE.org*, 2019. https://www.nspe.org/career-growth/nspe-code-ethics-engineers

[5] J. N. Garrett-Walker *et al.*, "Racial color-blindness and privilege awareness in relation to interest in social justice among college students," *Journal Committed to Social Change on Race and Ethnicity (JCSCORE)*, vol. 4, no. 2, pp. 39–63, 2018.

[6] A. Jackson, E. Barrella, and C. Bodnar, "Application of concept maps as an assessment tool in engineering education: Systematic literature review," *Journal of Engineering Education*, vol. 113, no. 4, pp. 752–766, 2024.

[7] M. A. Ruiz-Primo, "Examining concept maps as an assessment tool," in *Proc. of the First Int. Conference on Concept Mapping*, A. J. Canas, J. D. Novak, and F. M. Gonzalez, Eds., 2004.

[8] M. K. Watson, J. Pelkey, C. R. Noyes, and M. O. Rodgers, "Use of concept maps to assess student sustainability knowledge," in *2014 ASEE Annual Conference & Exposition*, Jun. 2014. Available: https://peer.asee.org/23238

[9] M. K. Watson, J. Pelkey, C. Noyes, and M. Rodgers, "Assessing impacts of a learning-cycle-based module on students' conceptual sustainability knowledge using concept maps and surveys," *Journal of Cleaner Production*, vol. 133, pp. 544–556, Oct. 2016.

[10] M. K. Watson and E. Barrella, "Using concept maps to explore the impacts of a learning-cycle-based sustainability module implemented in two institutional contexts," *Journal of Professional Issues in Engineering Education and Practice*, vol. 143, no. 2, 2017.

[11] M. Borrego, C. Newswander, L. Mcnair, S. Mcginnis, and M. Paretti, "Using Concept Maps to Assess Interdisciplinary Integration of Green Engineering Knowledge," *Advances in Engineering Education*, vol. 1, no. 3, 2009.

[12] A. R. Bielefeldt, "First-year students' conceptions of sustainability as revealed through concept maps," in *2016 ASEE Annual Conference & Exposition*, Jun. 2016.

[13] Segalàs ,J, FerrerBalas ,D, and and, “Conceptual maps: measuring learning processes of engineering students concerning sustainable development,” *European Journal of Engineering Education*, vol. 33, no. 3, pp. 297–306, 2008, doi: https://doi.org/10.1080/03043790802088616.
[14] Shallcross, David C, “Concept Maps for Evaluating Learning of Sustainable Development,” *Journal of Education for Sustainable Development*, vol. 10, no. 1, pp. 160–177, 2016, doi: https://doi.org/10.1177/0973408215625551.
[15] N. L. Schroeder, J. C. Nesbit, C. J. Anguiano, and Adesope, Olusola O, “Studying and Constructing Concept Maps: a MetaAnalysis,” *Educational Psychology Review*, vol. 30, no. 2, pp. 431–455, 2018, doi: https://doi.org/10.1007/s1064801794039.
[16] American Society of Civil Engineers, “Future Worlds,” *Future World Vision*, 2024. https://futureworldvision.org/why-future-world-vision.
[17] U.S. Council on Environmental Quality, “Climate and Economic Justice Screening Tool,” *Geoplatform.gov*, 2022. https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5
[18] The White House, “Ending Radical And Wasteful Government DEI Programs And Preferencing,” *The White House*, Jan. 20, 2025. https://www.whitehouse.gov/presidential-actions/2025/01/ending-radical-and-wasteful-government-dei-programs-and-preferencing/.
[19] E. Harbison, “Court clarifies that DEI executive orders are temporarily blocked for all federal agencies,” *Employment Law Watch*, Mar. 13, 2025. https://www.employmentlawwatch.com/2025/03/articles/employment-us/court-clarifies-that-dei-executive-orders-are-temporarily-blocked-for-all-federal-agencies/.
[20] National Academies of Sciences, Engineering, and Medicine, *Elevating Equity in Transportation Decision Making: Recommendations for Federal Competitive Grant Programs*. Washington, DC: The National Academies Press, 2023. doi: https://doi.org/10.17226/27439.
[21] National Academies of Sciences, Engineering, and Medicine , “Elevating Equity Considerations in Transportation Decision-Making — New Report,” *Nationalacademies.org*, Dec. 12, 2023. https://www.nationalacademies.org/en/news/2023/12/elevating-equity-considerations-in-transportation-decision-making-new-report.
[22] “U.S. DOT Orders Review of All Grants Related to Green Infrastructure, Bikes — Streetsblog USA,” *Streetsblog.org*, Mar. 12, 2025. https://usa.streetsblog.org/2025/03/12/breaking-u-s-dot-orders-review-of-all-grants-related-to-green-infrastructure-bikes.
[23] “Office of Environmental Justice & Equity,” *Colorado Department of Transportation*, 2024. https://www.codot.gov/business/civilrights.
[24] “Environmental Justice,” *Washington State Department of Health*. https://doh.wa.gov/community-and-environment/health-equity/environmental-justice.
[25] E. Kelderman, “Accreditor Urges Academe to ‘Rage’ Against Challenges to Higher Ed. It’s Also Revising Its DEI Standards.,” *The Chronicle of Higher Education*, Apr. 10, 2025.

https://www.chronicle.com/article/accreditor-urges-academe-to-rage-against-challenges-to-higher-ed-its-also-revising-its-dei-standards.
[26] D. S. Tharp, “Using Critical Discourse Analysis to Understand Student Resistance to Diversity,” *Multicultural Education*, vol. 23, no. 1, pp. 2–8, 2015.
[27] D. H. Lazenby, “Exploring student resistance to topics of diversity, social justice, and privilege: A critical content analysis of student evaluations of diversity instructors,” Auburn University, 2020.
[28] L. Fraade-Blanar, R. Best, and R. A. Shih, “Transportation equity for older adults,” Rand Corporation, 2022. Available: https://www.rand.org/content/dam/rand/pubs/perspectives/PEA1600/PEA1615-1/RAND_PEA1615-1.pdf.
[29] “Policy statement 418 - The role of the civil engineer in sustainable development,” *American Society of Civil Engineers*. https://www.asce.org/advocacy/policy-statements/ps418---the-role-of-the-civil-engineer-in-sustainable-development/.

Appendix A: Addendum (April 2025)

This Appendix reflects the authors' thinking about some of the changes that have occurred in the United States since the paper was originally written.

Change in Federal Policies

In early 2025 sweeping changes in federal government policies were made with respect to programs related to diversity, equity, and inclusion (DEI). For example, on January 20, 2021 Executive Order 13985, "Advancing Racial Equity and Support for Underserved Communities Through the Federal Government" was enacted. Four years later, this was rescinded by Executive Order 14151 "Ending Radical And Wasteful Government DEI Programs And Preferencing" [18]. DEI was characterized as "immense public waste and shameful discrimination." Within 60 days the federal government pledged to terminate "equity" actions, initiatives, or programs, "equity-related" grants or contracts, although the legality of these actions have been challenged in court [19]. At present (30 April 2025) the situation is uncertain and fluid, although the effects have been significant.

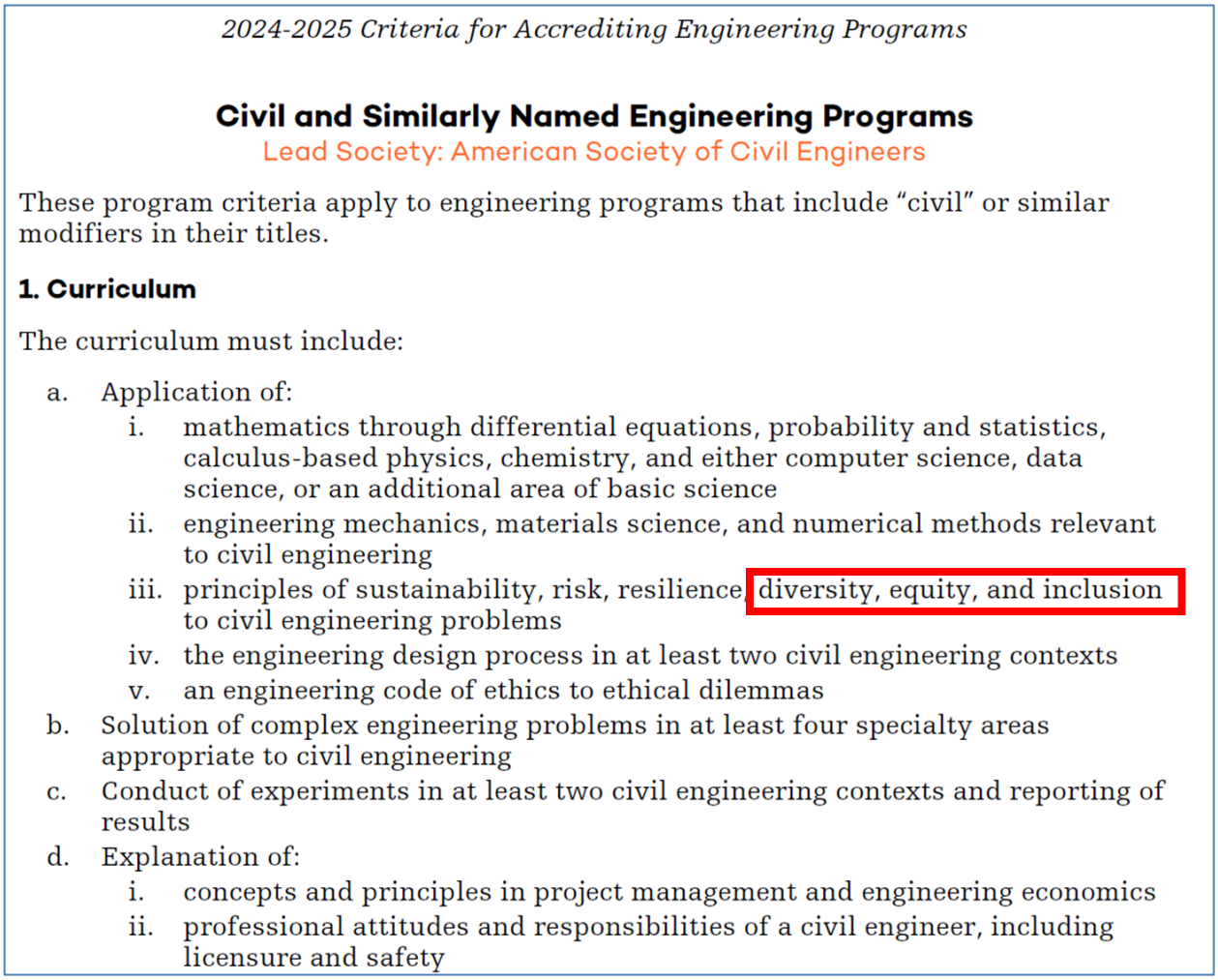
Infrastructure Design and Study impacts

The actions at the federal level leave a number of initiatives under uncertainty. For example, in 2024 the National Academies of Sciences, Engineering, and Medicine released a report promoting the notion of equity in transportation infrastructure [20] and two related studies were underway [21]. Further, the U.S. DOT has ordered that all grants related to bicycling and/or Green Infrastructure be reviewed [22] . The memo states: "The focus of this review is to identify project scope and activities that are allocating funding to advance climate, equity and other priorities counter to the Administration's executive orders."

Within some states, commitments to equity remain. For example, in Colorado the CDOT Office of Environmental Justice and Equity (EJE) [23] remains. Washington State's Environmental Justice Law entitled Healthy Environment for All (HEAL) remains in effect since its passing in 2021 [24].

Engineering Education Impacts

By February 18, 2025, ABET had changed its engineering accreditation requirements, meticulously removing all mention of DEI. Under ABET EAC Criterion 3, students no longer need an ability to function on teams whose members create an ***inclusive*** environment. The pilot criterion 5.d under Curriculum related to "content that ensures awareness of diversity, equity, and inclusion for professional practice consistent with the institution's mission" and associated definitions were gone. Perhaps most notably for civil engineering, the program criteria were changed from 2024-2025 by deleting the text in the red box in Figure A1. This change was apparently made without the involvement of ASCE. However, the equitable infrastructure issues are still very relevant to civil engineers based on the responsibility for ethical engineering and principles of sustainability.



2024-2025 Criteria for Accrediting Engineering Programs

Civil and Similarly Named Engineering Programs

Lead Society: American Society of Civil Engineers

These program criteria apply to engineering programs that include "civil" or similar modifiers in their titles.

1. Curriculum

The curriculum must include:

a. Application of:
   i. mathematics through differential equations, probability and statistics, calculus-based physics, chemistry, and either computer science, data science, or an additional area of basic science
   ii. engineering mechanics, materials science, and numerical methods relevant to civil engineering
   iii. principles of sustainability, risk, resilience, diversity, equity, and inclusion to civil engineering problems
   iv. the engineering design process in at least two civil engineering contexts
   v. an engineering code of ethics to ethical dilemmas

b. Solution of complex engineering problems in at least four specialty areas appropriate to civil engineering

c. Conduct of experiments in at least two civil engineering contexts and reporting of results

d. Explanation of:
   i. concepts and principles in project management and engineering economics
   ii. professional attitudes and responsibilities of a civil engineer, including licensure and safety

Figure A1. Civil Engienering Program Criteria (prior to February 18, 2025)

It also is important to acknowledge that many higher education regional accreditation bodies encourage student learning outcomes related to DEI, but this might be changing [25]. For example, the Higher Learning Commission (HLC) Criterion 3, Core Components 3B (in force thru August 2025; being removed as of Sept 1, 2025): "The education offered by the institution recognizes the human and cultural diversity and provides students with growth opportunities and lifelong skills to live and work in a multicultural world."

Risks

The rapid changes that have occurred since January 2025 introduce a variety of potential risks for teaching topics related to equity in first-year engineering courses. These risks are likely to make faculty and instructors more hesitant to integrate equity topics. These perceived risks come from students, other faculty members, administrators, and beyond. They are likely to vary significantly based on the local context of the engineering discipline, institution, and state. Previously these risks were lower for some. Within civil engineering, instructors could point to the program criteria in ABET as requiring these topics to be taught, which could be presented as

justification for both students and other faculty members who may have believed that these topics were not appropriate for teaching within an engineering course.

There are risks that students may push back when equity topics are introduced. This resistance might take a variety of forms, including vocally during class discussion, refusing to do assignments, or even retaliation against faculty via the anonymous student evaluation of teaching (SET) process [26; 27]. The SET process may be particularly concerning for non-tenured faculty, whose job may be at risk if many students rate the teaching and learning experience poorly.

There also are risks that other faculty members or administrators may view these topics as not legitimate to teach in first-year engineering courses. Some states are taking care to remove DEI topics under pressure from legislation to avoid perceptions of indoctrinating students. Engineering faculty may believe that engineering courses should be more technically focused (a problem even before the recent federal transition). These faculty are in positions to rate the performance of instructors through annual merit review and reappointment, promotion, and tenure reviews. Individuals should carefully weigh these topics as they make teaching decisions.

Recommendations for First-year Courses

Within the context of teaching first-year courses, we recommend that individuals be sensitive to their local institutional context and policies in different states. Universally, instructors can focus on the importance that infrastructure benefit everyone in a community. An example that should not be divisive or controversial is equity for older adults [e.g., 28]. Instructors should consider careful use of terms and language when discussing equity issues. Responses have already included changing the title of a course at one institution. Faculty might also rename assignments to avoid controversial and potentially divisive terms that would draw attention to these issues within course syllabi. Instructors may also need to adapt teaching methods because some resources might no longer be available or will no longer be updated. For example, the US EPA will no longer be updating EJSCREEN, the Environmental Justice Screening and Mapping Tool, and the tool is no longer found on the current US EPA website (https://19january2021snapshot.epa.gov/ejscreen_.html). The authors are all considering how best to modify their courses.

The ABET Civil Engineering program criteria still require education on ethics and sustainability. The ASCE code of ethics includes ideas related to equity such as 1. Society, “g. acknowledge the diverse historical, social, and cultural needs of the community, and incorporate these considerations in their work”, 2. Natural and built environment “c. mitigate adverse societal, environmental, and economic effects”. Principles of sustainability are discussed in ASCE Policy Statement 418 [29], which refers to the Envision Rating System. And within Envision, criterion QL3.1 is Advance Equity & Social Justice. Thus, a focus on sustainability or resilience might be a good vehicle for discussing equity. It is important to consider that everyone has particular definitions for complex ideas and terms. Instructors must be particularly sensitive to these issues around DEI, sustainability, ethics, and other ideas. Equity issues are still highly relevant for all engineers and teaching students about these topics continues to be critically important.

Appendix B: Gonzaga University Assignment

Homework 7: **Equitable Infrastructure (Justice, Equity, Diversity, Inclusion - JEDI)**

Complete all of the 4 items below:

1. Select one of the options (a to g) from the list below; i**dentify** which you read / watched / used. **Describe** at least **two** elements that stood out to you. [4 pts]

2. Select a second item (a to g) below; identify. **Describe** at least **two** elements that stood out to you. [4 pts]

3. **Discuss** why JEDI issues are of concern in civil engineering. [1 pt]

4. **Discuss** the ways that JEDI issues might affect you personally in your future career and work. [1 pt]

Write up should be 250-500 words. Submit an MS Word file (preferred) or PDF. include your name and the word count.

(a) JEDI in FWV MegaCity2070 (there are JEDI elements embedded in the scenario; could also find some of these) https://www.futureworldvision.org/ Identify JEDI issues and comment – to what extent these appear significant, important impacts on this attribute due to civil engineering.

Easiest is top right 'search' and pulldown menu 'Ethics + Equity' (Prof B did this and got 42 results, but not all obviously JEDI oriented)

(b) Climate and Economic Justice Screening Tool (CEJST). Use the tool and explore your hometown or CU Boulder area. Compare a "disadvantaged" area to a geographically adjacent NOT disadvantaged area. The attributes most related to civil engineering are: transportation; water and wastewater; legacy pollution. Discuss how civil engineering can reduce these inequities. https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5

(c) Engineering more equitable Communities, 12-min video, Autodesk https://www.autodesk.com/autodesk-university/content/Engineering-More-Equitable-Communities

(d) Delivering Equitable Infrastructure : a case study of Baltimore. AECOM. https://digital.aecom.com/article/delivering_equitable_infrastructure_a_case_study_of_baltimore/

(e) National Society of Professional Engineers (NSPE) Why Should I care about diversity in Engineering? 2020 [reading] https://www.nspe.org/resources/pe-magazine/july-2020/why-should-i-care-about-diversity-engineering

(f) How Diverse Teams Drive Innovation, 22-min video, Migual Alemany interview by American Society of Civil Engineers: https://www.asce.org/publications-and-news/civil-engineering-source/article/2022/06/15/how-diverse-teams-drive-innovation-part-1

(g) ASCE Examining social equity in infrastructure; ~25-min, Maya Trotz

https://www.youtube.com/watch?v=Vy1wHvPlGi0&list=PLA61bxD8Jg-2ZiW3R-EabzvFVNJda_KvH&index=6

Appendix C: Example Concept Maps

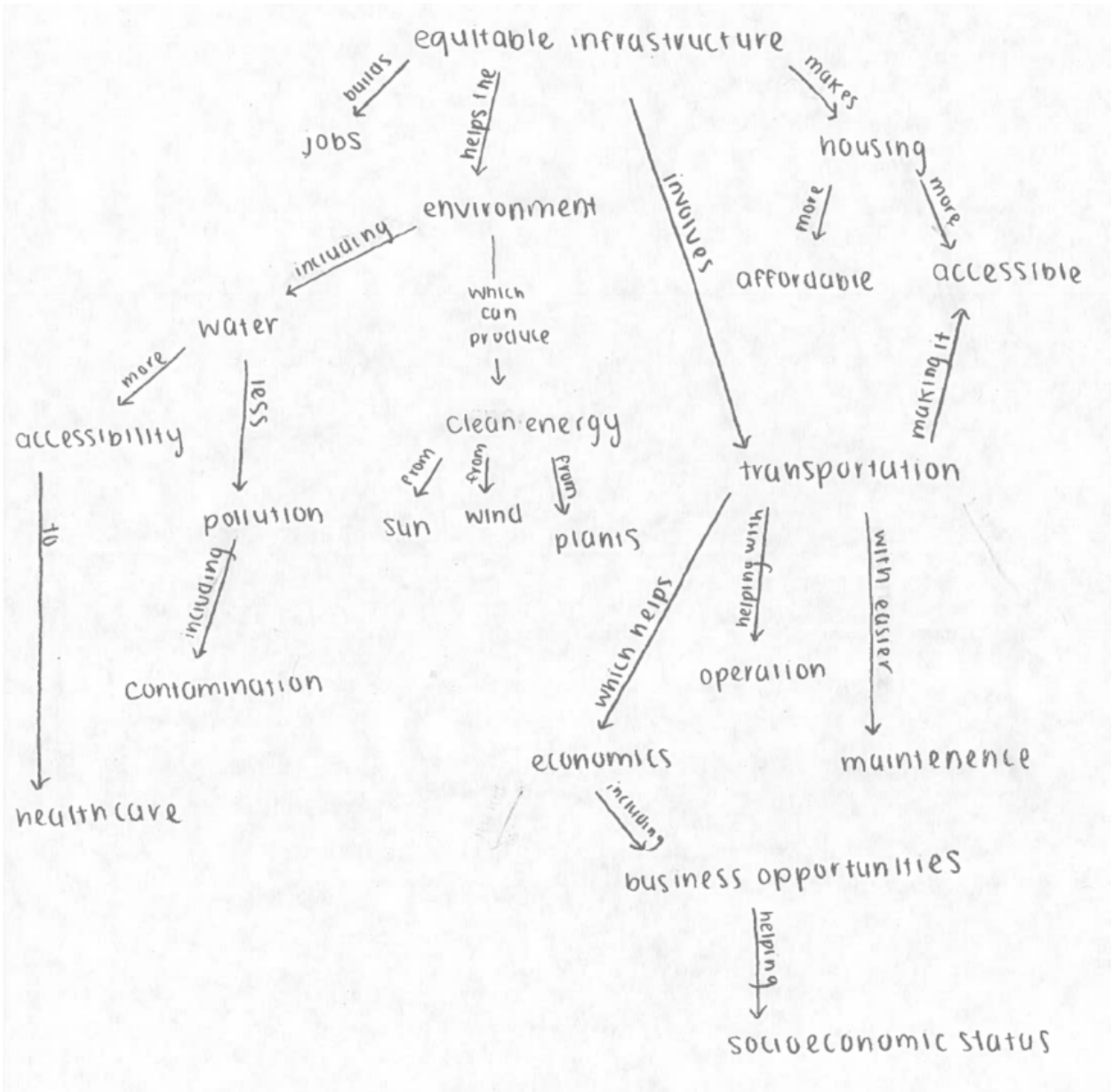


Figure C1. Example "balanced" initial concept map from Lafayette College, Student #6.

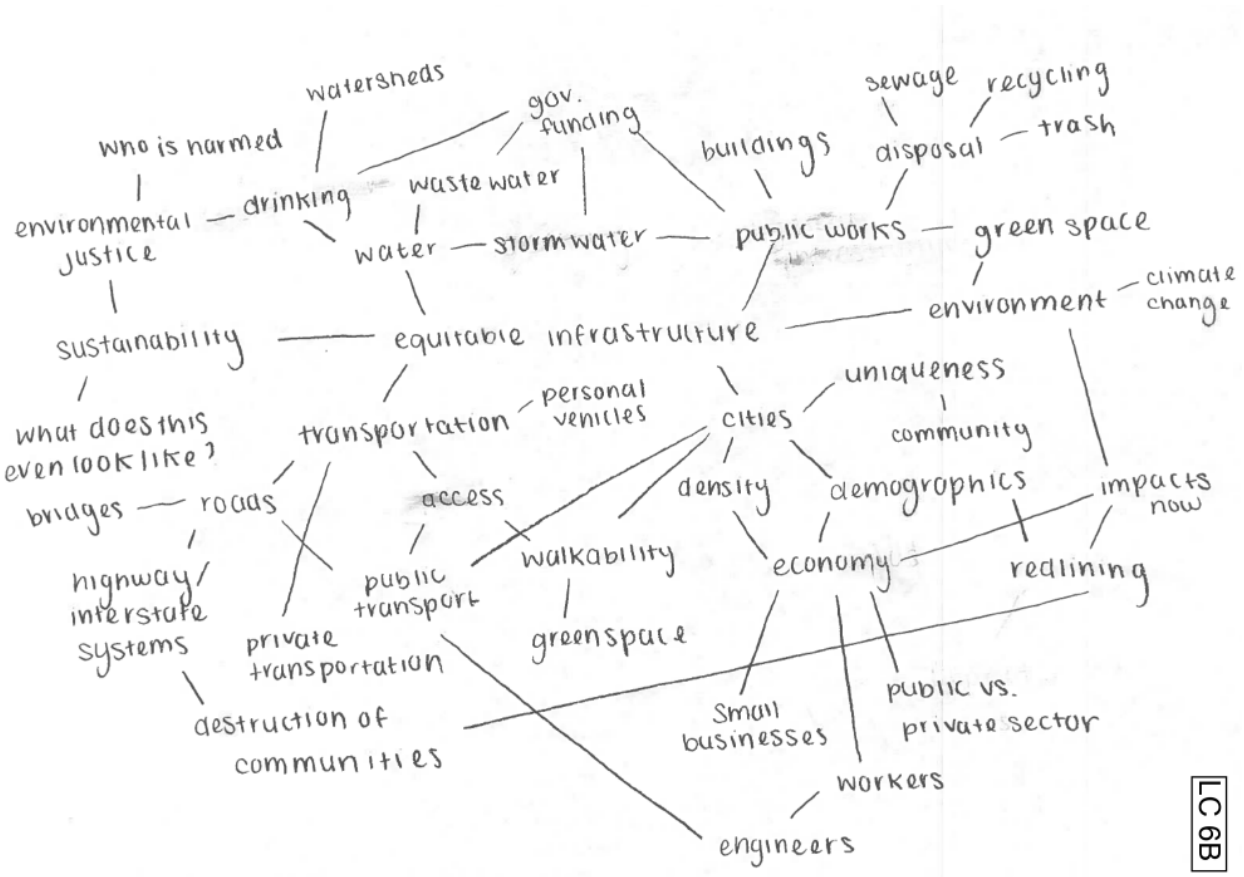


Figure C2. Example "balanced" final concept map from Lafayette College, Student #6.

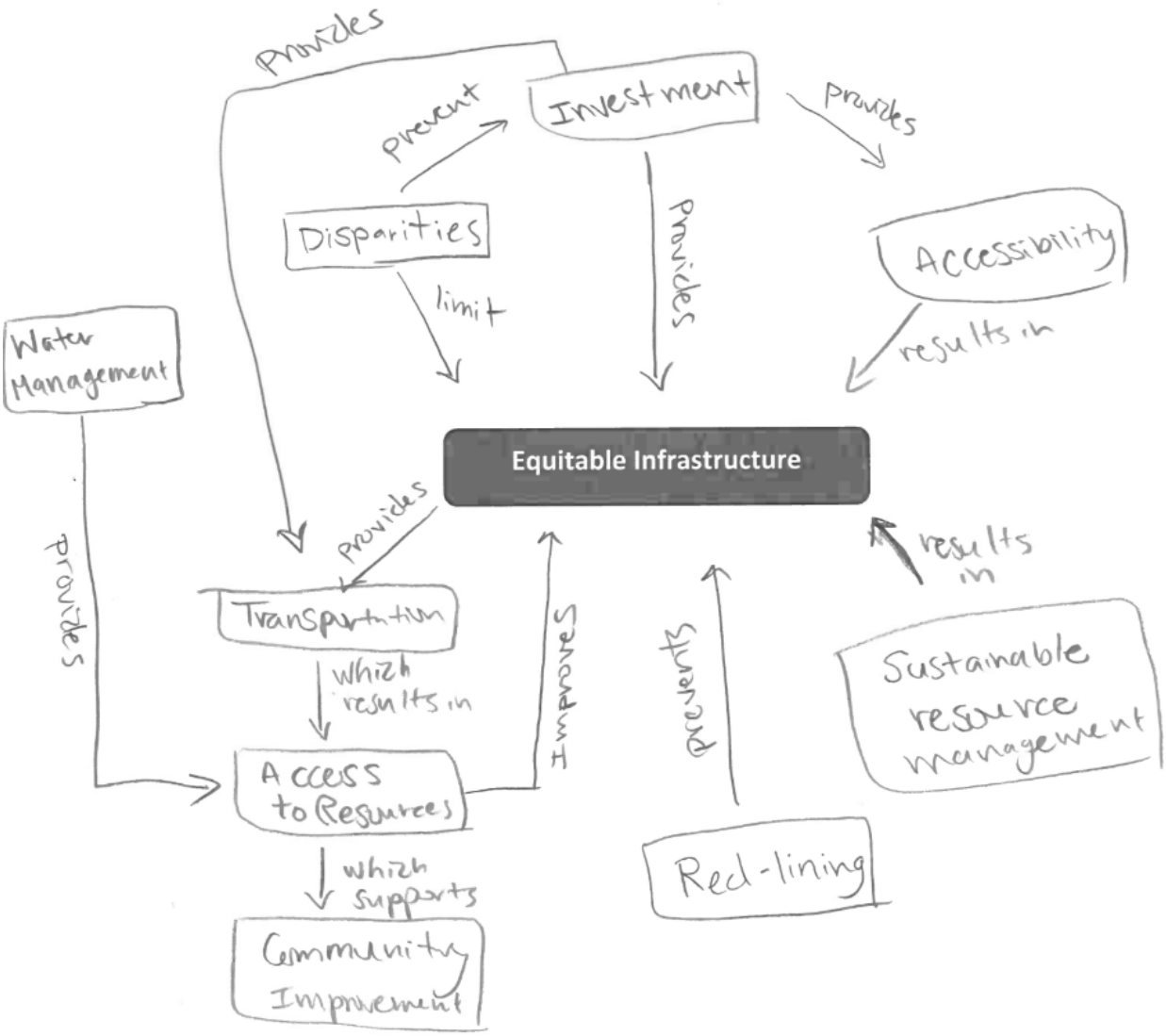


Figure C3. Example of "Equity" initial concept map from Gonzaga Unveristy.

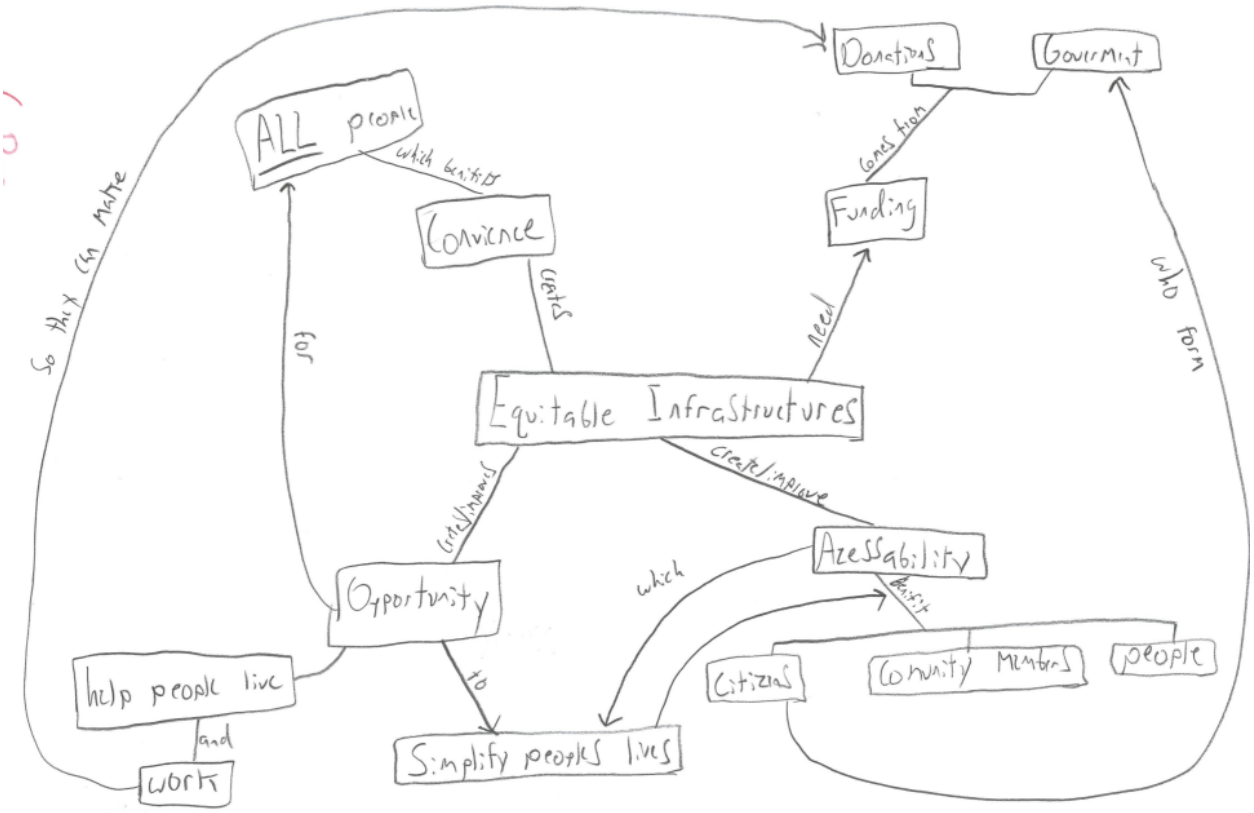


Figure C4. Example of "Equity" focused initial concept map from Tufts University, Student #6

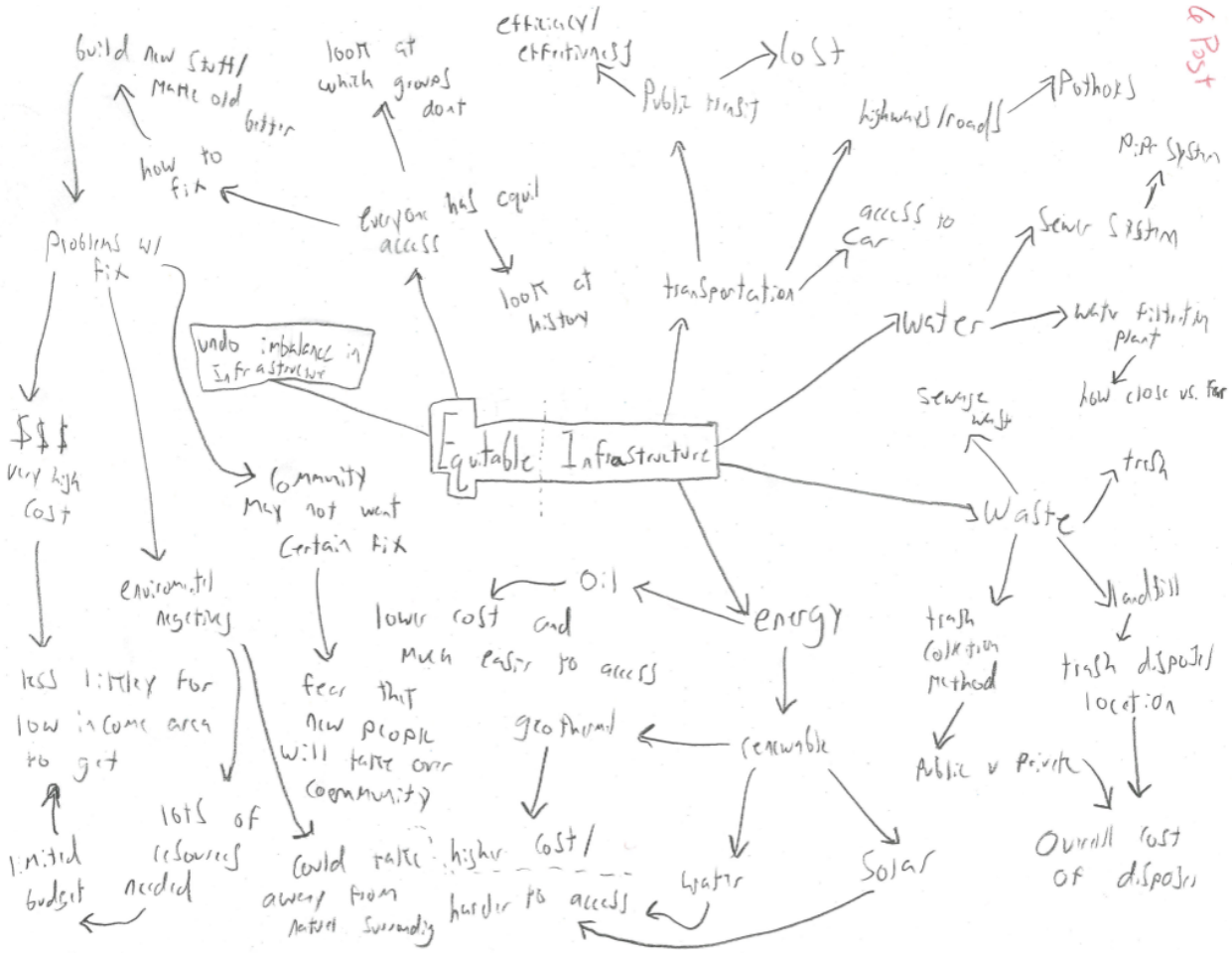


Figure C5. Example of "Equity" focused final concept map from Tufts University, Student #6