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Environmental Justice and Equity Issues: In Our Backyards and Beyond

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Abstract

This paper presents three models for integrating environmental justice topics into environmental / civil engineering courses. The first model utilizes a qualitative perspective, based on a video recording of the community panel at the 2019 American Society for Engineering Education (ASEE) Annual Conference. This panel provides numerous examples of environmental justice issues from the lived perspective of residents, including issues associated with industrial air pollutants from Tonawanda Coke in New York and drinking water in Milwaukee, Wisconsin, and Flint, Michigan. Segments of this video were integrated into a fall 2020 course for first-year civil engineering students, in relation to the assignments on ethics and sustainability. The details of these assignments and an analysis of student learning are provided. A second model studied the Flint water system disaster in the context of learning about community resilience and systemic racism within a senior/graduate level Civil Engineering Systems course. The decades-old discriminatory practices in housing (redlining, racist mortgage covenants) were discussed. Student perspectives based on the threaded discussion posts and a written assignment provide evidence of the effectiveness of this approach for learning about how non-technical factors are important in determining public infrastructure performance. A third model recommends the use of environmental justice mapping tools, which may be appropriate in a broad range of courses. Examples are provided, but have not yet been used by the authors. These examples present ideas to spur the integration of environmental justice topics into civil and environmental engineering courses, while also inviting programs to more broadly consider an intentional across-the-curriculum approach.

Background

Diversity, equity, and justice issues have garnered increased attention in 2020 as public outrage over the deaths of George Floyd, Breonna Taylor, and many others exploded. This led to broader acknowledgement of systemic racial bias and inequalities in society at-large and within higher education. In 2020 a number of institutions newly required the integration of justice, equity, diversity, and inclusion (JEDI) issues into students' education, via online modules for students and/or integration into courses [1,2]. For example, the California State University system added a new requirement for students to take a social justice or ethnic studies course [3]. Many institutions were more proactive in this regard and already had these requirements in place; e.g., Dartmouth [4] and Tulane [5] required diversity and inclusion training for all incoming students via orientation / online learning; Humboldt State requires two diversity and common ground courses for all students [6]; San Diego State University requires one cultural diversity course as part of the general education requirements [7]. While important, it is unclear to what extent these JEDI modules make specific ties to engineering issues. As future professionals whose work has significant societal impacts, it is imperative that engineers connect their work and responsibilities to JEDI topics. Within environmental engineering, there are rich opportunities to address JEDI topics from the perspective of environmental justice.

Environmental justice (EJ) encompasses a variety of topics and concerns [8,9]. At its most basic, EJ focuses attention on inequities in the distribution of negative environmental conditions.

Historically, toxic dumping and the location of undesirable land uses have followed the "path of least resistance," where minority and poor communities have been disproportionately burdened with these types of externalities [10]. These inequities typically disproportionately impact low income communities and/or communities of color, resulting in both direct negative health impacts and mental stress. Environmental conditions include traditional "pollution" perspectives related to air and water quality, as well as more expansive environmental conditions in both urban and rural settings, protection of nature and endangered species, climate change, natural resource depletion, sustainability, and environmental disasters. EJ encompasses a "multidimensional web of factors" including race and ethnicity, education, jobs, home ownership and value, and government policies [11]. EJ concerns also intersect with broader social justice concerns of power and oppression [12]. *Dumping in Dixie* discusses the "assumption that all Americans have a basic right to live in a healthy environment… the issues addressed center on equity, fairness, and the struggle for social justice by black communities." [11] Justice draws attention to "equity, recognition, and participation" [8]. Participation and interactions that value different perspectives and avoid a deficit model are key conditions for social justice [13].

The term 'environmental justice' appeared in 80 conference papers associated with the American Society for Engineering Education (ASEE), based on a search in the ASEE PEER system [14]. The majority of the EJ conference papers were associated with the Liberal Education / Engineering and Society (LEES) division (11), Engineering Ethics division (11), and Environmental Engineering division (7). However, EJ only appeared in the title of two papers, both authored by Roger Painter [15, 16]. Baillie's ASEE conference paper [17] promoting working towards "engineering education for social and environmental justice". The ideas were grounded in Transformative Learning Theory and Threshold Concept Theory. A multidisciplinary group of educators from engineering, education, and humanities developed a list of 36 keywords that identified potential threshold concepts. In addition, intersectional issues between eight different disciplines and engineering were presented. Significant works that focus attention to the intersection of SJ and engineering, with some acknowledgement of environmental issues, include Leydens and Lucena [18] and Riley [19].

In this paper we present three different examples of integrating environmental justice issues into courses for environmental and/or civil engineering students. The first two examples have been used in courses by the authors; teaching practices and assessment of student learning outcomes are described. The third example is speculative, potentially broadening the range of courses where environmental justice issues can be integrated.

Case study: Community Panel Video

Environmental justice issues were integrated into a course for first-year engineering students. This section describes the genesis for designing the module, the specifics of the assignment and lecture for the students, and a summary of the outcomes assessment.

At the 2019 ASEE Annual Conference there was a moderated panel of five community members describing their interactions with engineers [20]. Each of the five speakers shared stories related to EJ issues; in brief:

- Sydney Brown, Buffalo NY, clean air issues, Tonawanda Coke

- E. Yvonne Lewis, Flint MI, lead contamination in drinking water
- Robert Miranda, Milwaukee WI, lead in drinking water
- Albert P. Naquin, Isle de Jean Charles LA, land washing away with sea level rise
- Lena Young-Green, Tampa FL, interstate highway impacts on local residents

The panel was video recorded, and the recording is available online [21]. Segments of the video were shown and discussed in three different courses in fall 2019: a first-year introduction to civil engineering course, a senior-level professional issues course in civil engineering, and a senior/graduate level course in site remediation/hazardous waste management. During these implementations, students were directed to practice their listening skills toward realizing learning outcomes related to ethics and sustainability; these results have been previously described [22]. The genesis for this idea was the ethical listening work from Lambrinidou and Edwards [23-25]. Based on the vitality of the in-class discussion, the most successful implementation was in the senior/graduate level site remediation course, followed by the first-year course; the integration into the senior professional issues course was not successful.

The integration of the community panel video was modified in the first year introductory civil engineering course in fall 2020, due in part to the COVID pandemic which required the course to be taught online. One framing principle in the course was the idea of human centered design for infrastructure, which allowed the diverse array of topics covered in the course to have some cohesiveness. As part of the ethics and sustainability modules in the course, students were asked to read assigned material and watch segments of the ASEE community panel video on their own time, then answer a series of questions as part of the associated homework assignments. Because the course was 1-credit, the intent was for the assigned reading, video, and assignment to take about 2 hours of student time outside of class for each of these two modules. A discussion on the homework was conducted in-class after the assignment was submitted. These discussions were primarily situated in ZOOM breakout rooms with groups of 4 to 5 students. (The quality of these discussions was not observed by the instructor.) There were 56 students enrolled in the course. A summary of the ethics module is given in Table 1.

Table 1. Ethics module in one-credit first-year civil engineering course

Reading	Penn & Parker [26], Ch. 17 Ethical Considerations ASCE 2017 Code of Ethics [27]
Video segments (time range)	Introduction to the panel and its purpose by Nathan Canney (0-1:45 min) and Yanna Lambrinidou (4:36-5:58 min) Tampa community member Lena Young-Green (14:34-15:00 min and 46:06-53:50 min) Concluding remarks by moderator Darshan Karwat (53:50-56:52 min).
Assignment (300 to 500 words in length)	(a) Discuss two or three ethics canons (including specific sub-parts) that relate to the situation described with the interstate highway system and local community in Tampa Florida. Summarize each canon, how it relates, and in what ways the situation appears ethical or unethical in relation to the codes. (b) It what ways does the code of ethics appear to fall short of considering the benefits/harms to the local community of the speaker? What did you find most compelling from Lean Young-Green? (c) How does the skill of listening relate to ethical engineering?
In-class student break-out discussion	Did anything surprise you in the ASCE Code of Ethics? Did anything seem missing from the ASCE Code of Ethics? What were your thoughts based on listening to the panel video? Discuss ethical issues pertinent to bridge design (linked to class project)

Content analysis on the 52 submitted written assignments was conducted by the first author after the completion of the semester (students were allowed to drop 2 assignments during the semester, and 4 did not submit this assignment); results are summarized in Table 2. The majority of the submissions were 250 to 500 words, with a median length of 400 words. The students performed well, with 90% receiving A grades, and the remaining 10% B or C grades. Only one student appeared to have not watched the video, based on providing a generic summary of all 8 codes and how they related to civil engineering in general. The remaining students all discussed portions of the video, but a few did not discuss the Tampa transportation situation but had watched other parts of the video that discussed lead in water in Milwaukee WI and Flint MI.

Table 2. Content analysis of ethics homework in the first-year course

Canon in ASCE 2017 Code of Ethics [27]*	# students linking to situation	Summary and/or Example quote
1. Health, safety, welfare paramount; protect environment & sustainability	39	LYG examples of negative respiratory effects from air pollution from the highway (health), community cut in half by highway (welfare)
2. Service with competence	6	Not a competent design due to 'malfunction junction' described by the speaker, or lack of listening to community
3. Issue true statements	14	Lack of engineers extending public knowledge of the project and/or unfair statements; "Young-Green discussed that they showed the community plans of one highway that was still affecting them but went with another design. She described how often the initial plan was not exactly what they were going to follow through with."
4. Act as faithful agent	10	[frequently misinterpreted the meaning on conflict of interest as conflicting interests among different groups in Tampa – e.g. commuters vs. locals]
5. Reputation by merit	0	
6. Uphold professional honor	6	"These engineers were violating canon 6 (specifically parts a,b and e), and therefore being unethical because they did not express to their employers and clients all the negative consequences that building this interstate will cause on the community around it."
7. Continue professional development	2	"engineers working in the Florida area should remain updated on the demands of the community. They should stay up to date on the community requests and the environment where they are working"
8. Treat all persons fairly	28	"The second canon of relevance is number eight, to treat all persons equally. In placing the highway system through an economically poor neighborhood, the engineers may not have considered all options but rather selected the least expensive option with the smallest degree of push back from community members."

* Pre-dated the 2020 release of the new ASCE Code of Ethics [28]

The most common ASCE ethics code canon that the students linked to the Tampa situation was the paramountcy clause, largely based on the negative health effects of the highway and to a lesser extent the community welfare impacts described by Lena Young-Green (LYG).

The second most common was the new Canon 8 which explicitly states, "8c. Engineers shall consider the diversity of the community, and shall endeavor in good faith to include diverse

perspectives, in the planning and performance of their professional services." [27] The instructor actually expected most students to discuss this canon due to the clear lack of these considerations in the history of the Tampa interstate. However, if students read only the textbook chapter and not the ASCE code, they may have been unaware of this canon, which was added to the ASCE code in 2017. While many students discussed this code, a smaller number were explicit in identifying the characteristics of the community, as related to social justice issues such as income (n=14) or racial minorities (n=10). Most did not comment on equity issues regarding race or income. Those students' discussion focused on a local community, with the sense that any local community might be impacted. But not why this community.

Many students focused on the engineering technical issues related to the highway problem (37%; an unsafe road design, engineering solutions to the problems), while a number also discussed the negative health impacts to the locals cited by LYG (38%). Few students discussed the more 'emotional' side of LYG in relation to the situation.

Overall, requiring the students to tie the code of ethics to the situation described by LYG on the Tampa highway system seemed to work moderately well. If the instructor had time to read the student reflections in the homework prior to class, a richer discussion could have been facilitated. It was interesting to see what elements students picked up on. For example, some misinterpreted or seemed to minimize the situation.

The ethics assignment was followed by a lecture and homework assignment on JEDI. JEDI was integrated into the course as a required CU101 topic for all first-year students. The campus provided JEDI information to include, so this was a missed opportunity to provide a rich discussion on JEDI issues highlighted by the speakers. A few students seemed to confuse the concepts of equal, equity, and justice in their ethics assignment, which we discussed during the JEDI week. (During the JEDI module students selected among a variety of short readings / podcasts [29-34] and wrote a reflection, followed by in-class discussion.)

The following week, the course focused on sustainable engineering. The module is summarized in Table 3.

Table 3. Sustainability module in the first-year civil engineering course

Reading	Royal Academy of Engineering [33], Chapter 1 (pg. 7-10) and Chapter 3 12 principles (pgs. 25-31)
Video segments (time range)	Chief Albert P. Naquin from Isle de Jean Charles (12:53-13:54 min, 30:57-38:09 min)
Assignment (300 to 500 words)	1. Define sustainable engineering, in your own words. 2. From among the 12 principles of engineering for sustainable development that are presented in the RAE report, select two or three that you find the most related to the community of Isle de Jean Charles and its issues that relate to civil engineering. For each of the two or three discuss why you picked it and how it is relevant. (*just a couple of sentences for each, since your total write-up is still targeted to be under 500 words)* 3. What one element from Chief Albert's presentation did you personally find the most impactful.
In-class student discussion	Zoom poll: Which of the 12 principles seemed most relevant to Isle de Jean Charles? Followed by discussion. Discuss which of the ENVISION [34] rating system credits seem most relevant to your bridge design [related to class project]

The students performed very well on the homework assignment, with 96% earning an A and 4% earning a B or C. The results of content analysis from the student homework assignments is shown in Table 4. Table 4 paraphrases the 12 sustainable engineering principles (listed in the order presented in the report), the number of students who linked this principle to the situation of Isle de Jean Charles, and provides an example student quote from the homework assignment.

Table 4. Content analysis of the sustainability assignment in the first-year course

Sustainability Principle RAE	# students[A]	Example student response quotes
look beyond own locality & immediate future	17 [5]	…'Your work impacts people, communities, and the landscape'. Both of these statements tell the engineer to think outside of himself and create something for the benefit of all living things, present and future.
innovate and be creative	4 [2]	In this situation with the rising water levels, the engineers need to come up with a new and clever idea to save this area… so [residents] do not get flooded out of their own town. … a basic solution that may have been tried in the past, may not work long term or may not necessarily be sustainable. Innovation in this scenario is key
seek balanced solution	17	'Realistic sustainability…' Engineers must find a balance between their goals for the project and the byproducts produced by it. This relates to the Isle de Jean Charles because there must be a balance not only between environmental factors, but between traditions and the new way of doing things.
engagement from all stakeholders	16 [3]	The grant was going to be something that would make the tribe more environmentally safe and reunite them together. It would be civil engineers jobs to help make that a reality and understand the best way to help these people. The government said to the tribe that they weren't going to consider their concerns and ignored the tribe's grievances. They also were very disrespectful and inefficient at finding engagement, there was initially a rule that states they couldn't go onto their land without asking their permission first and informing them of it and they blatantly disregarded it.
know the needs and wants	21 [3]	As Chief Naquin discussed, the original engineers and others involved in the project did not ignore these wants and needs, but the government overlooked these issues.
plan and manage effectively	6 [4]	in the state of Louisiana there is a thorough process of verifying and constructing the community that will hopefully help future relocations. This detailed process follows the exact definition of the sixth principle with the care, time, and money that is being spent.
give sustainability any benefit of the doubt	1 [1]	One of Chief Albert's takeaway points was that engineers should be aware of how decisions affect people, communities, and landscape. Understanding sustainability comes from having respect for the environment and the people that live in the areas you'll affect and taking his words into consideration and understanding that you have to be sustainable in practice is essential.
polluters must pay	2 [5]	You have a responsibility to be aware of the negative impacts of the work you engage in…
holistic cradle to grave approach	2 [2]	This one relates most to Isle de Jean Charles, because one of the problems that plagues the Isle is flooding, both from hurricanes and severe rain. By building their houses above the ground and elevated the flooding of housing can be avoided. And by taking a holistic cradle to grave approach these houses will be constructed using long lasting environmentally safe materials. By doing so, projects will last through our generation and the next.
do the right thing and do things right	2	OCD clearly did not to the right thing in this case. They failed to 'decide on appropriate actions to be taken' and instead focused on their profit and goals as opposed to the welfare of the tribe. The OCD and the tribe were meant to work together, and instead the OCD turned their backs and failed to use the federal money to the full benefit of the community

Sustainability Principle RAE	# students[A]	Example student response quotes
beware cost reductions…	0	
practice what you preach	3 [5]	Essentially the OCD used the Native Americans to acquire a large grant but once the land was actually purchased, the state completely threw out the actual goals of the project. While they preached to the US government that they needed the grant to help the people of Isle de Jean Charles, once acquired the state's own interests became the focus of the grant…. if they were to practice what they preached then they would give the land to the Native American people as it was intended to do.

[A] Additional students who did not specifically link to Chief Naquin's comments

Only 41 students identified RAE principles that related to the Isle de Charles community; Superscript numbers represent those among the additional 12 students who identified RAE principles related to civil engineering broadly or some of the other communities in the video. In some cases, it was unclear that students understood the meaning of the word stakeholder, from the fourth principle. Students picked up on specifics from Chief Albert's presentation, including quoting some parts of his discussion. Examples are provided below.

> *words for engineers: "Your work is more than plans and specifications. Your work is more than creating a design for a client. Your work impacts people, communities, and the landscape. You have a responsibility to be aware of the negative impacts of the work you engage in." A reminder to keep community in mind in every step of the process….*
>
> *One element from Chief Albert's presentation that I personally found most impactful was the list of his Tribe's values. When I read the RAE report about sustainability, I only thought about the impact that civil engineers have on resources. However, after listening to Chief Albert's presentation, I have learned that sustainable engineering also impacts people's values as in the case of the community of Isle de Jean Charles. As a result, I am* ***shocked*** *that the state of Louisiana ignored their values and instead "divided and conquered" the Tribe's community.*
>
> *Chief Albert and his group of tribe members have a plan to install the core values and teach the Indian tribe's culture. He wants to keep the tribal community together that dispersed all over. He is determined to fight for what is right and needs help from the engineers to understand and listen to the needs of tribes. The state of Louisiana completely ignored the plan the chief has proposed to install safety, sovereignty, sustainability, and self-sufficiency community for his tribal family but is* ***tenacious in his pursuit of justice****.*
>
> *What was particularly striking about Chief Naquin's discussion was that a major reason the community's wishes were overlooked was because of Isle de Jean Charles being a Native American community.* ***It's very disappointing to see that these issues are still arising*** *within the engineering community as it makes sustainable engineering very difficult to achieve on the social side of the issues. If sustainability within a community is unable to be achieved, then it is more difficult to achieve sustainability in regard to the environment and resources available. In order for sustainable engineering to be achieved, both resources and the community must be able to provide for future generations.*

The majority of the students gave a personal definition of sustainable engineers that focused on environmental issues. Listening to the community members drew attention to the social aspects of sustainability. Two students also discussed Chief Naquin's discussion of "realistic

sustainability". This idea was an excellent bridge to the next topic in the course which was creativity and innovation. A number of the innovative developments in civil engineering relate to improvements in sustainability.

At the end of the semester, students wrote a reflection piece on civil engineering and what they had learned over the semester. There were not specific prompts that asked them to discuss the community panel or environmental justice issues. However, among the various requirements, students were instructed to:

- Demonstrate understanding of the essence of civil engineering, discuss what you learned about civil engineering during the semester.
- Discuss why ethics and sustainability are important to civil engineering (in a few sentences)

Within the final essays, all of the students discussed the obligations and responsibilities of civil engineering toward communities, society, and/or people/individuals. For 80% of the students this potential for civil engineers to benefit communities, people, and/or society inspired and/or motivated them to be an engineer. Discussion of community issues was far more common among the final student essays in 2020 compared to previous years when the course had a similar final reflective assignment but not the course content structured around the community panel (e.g. 84% in 2020, 57% in 2019, 45% in 2018, and 52% in 2017). Thus the personal stories of community members seemed to make the ethical obligations and sustainable engineering come alive for students. There were 36% of the 56 students who directly discussed the community panel in their final essay, either when defining civil engineering and/or later in their discussion of the importance of ethics and sustainability for civil engineers.

A particularly noteworthy example from a student's final essay is:

> *The ASEE panel showed that people are listening to communities and what they have to say. Engineers are now far more dynamic in their approach to helping the communities they serve. If the essence of engineering is to solve problems then it must include a diverse set of voices in deciding what is the solution. I intend to be the ear that listens to these voices. …. The two largest driving forces of my engineering degree are sustainability and ethics. I believe ethics can be greatly improved by diversifying the voices who have a seat at the table. I also believe we are the generation that will make great strides at being more conscious both racially and environmentally. We must challenge ourselves to leave the echo chamber and to hear ideas that might conflict with our thinking. (Looking at you Mellon Arena, maybe don't destroy a thriving black community for the next 60-70 years for a hockey arena.) ….*

Another rich example is:

> *During this semester I learned more about what it means to be a civil engineer and the elements that are necessary to be a good civil engineer. There were nuances that I never even would have thought about it being needed to become a good civil engineer, such as the ethics involved. One of the most surprising ethic mentioned in the ASCE Code of Ethics was the social concerns of the project. This was something that caught me off guard being mentioned in a code of ethics, because I never even thought about how civil engineering can cause concerns in those areas. While watching the ASEE Community Panel video and hearing from Lena Young-Green as a community member that had the firsthand experience of what happens when this ethic is considered, it opened my eyes to how it is one of the more important ethics in the ASCE Code of Ethics…. Something that I found inspiring about civil engineering is the process of helping the people in the area and improving their quality of life. I was inspired while reading about sustainable development and hearing from Chief Albert P. Naquin.*

Chief Albert P. Naquin's story about how the people on the Isle de Jean Charles were treated by the engineers that were there to find a solution that was in line with the best interest of the native people there, not the government. …This also led me to be inspired to be considerate of the situation, with the social concerns being considered to prevent situations like Lena Young-Green's and Chief Albert P. Naquin's from happening during my time being a civil engineer.

Overall, the integration of the community panel that focused on environmental justice issues was well received by the students. The implementation in 2020 was superior to the integration in 2019. Within courses that have already integrated ethics and/or sustainability issues, instructors can draw attention to environmental justice issues via the stories of community members. The method used in this civil engineering course would be fully compatible with similar introduction to environmental engineering courses for first-year students.

Case Study: Civil Engineering Systems

Civil Engineering Systems is a combined senior undergraduate and graduate level course with the objective of applying systems analysis methods to civil infrastructure systems: transportation, water supply and wastewater, solid waste, across all phases of a project life cycle. One major learning objective is applying methods of characterizing and modeling these system behaviors during its life cycle, and one of the system characterization topics was the analysis of resilience. In fall 2020 there were 6 undergraduate students and 5 graduate students enrolled in the course.

The students studied a model for infrastructure resilience proposed by Bruneau et al. [35] which incorporates two sets of resilience attributes. The two sets of dimensions produce a matrix model of system behavior under a disruption event (see figure below).

		PHYSICAL INFRASTRUCTURE DIMENSIONS			
		ROBUSTNESS	REDUNDANCY	RESOURCEFULNESS	RAPIDITY
COMMUNITY DIMENSIONS	TECHNICAL				
	ORGANIZATIONAL				
	SOCIAL				
	ECONOMIC				

After discussing this resilience model, students were assigned to apply it to the Flint water system failure that occurred between 2013 and 2016. One component of the assignment focused on applying an environmental justice framework to the resilience model of the Flint water crisis. In addition to technical and chronological reports, the students read a 2017 report by the Michigan Civil Rights Commission, "Flint Water Crisis: Systemic Racism Through the Lens of Flint," which describes "systemic racism" as the result of decades-old discriminatory practices in housing (redlining, racist mortgage covenants) and employment [36].

One part of a written assignment was, "Read the 2017 Report of the Michigan Civil Rights Commission, 'The Flint Water Crisis: Systemic Racism Through the Lens of Flint.' Referring

back to your resilience matrix, describe the role "structural racialization," referred to in the Report, played in the community resilience characteristics." Table 5 below shows the student responses as they mapped them into the resilience matrix model. In general, redundancy was not featured in the students' models. The matrix dimensions for infrastructure with the most significant number of comments were in the robustness dimension, followed by the resourcefulness dimension. The community resilience dimensions most cited were organizational (government actions), social, and economic. Interestingly, although the Flint water infrastructure had significant technical vulnerability (aging, lead pipes, corrosive and contaminated water source), students wrote more about the role of the broader dimensions of community resilience in the crisis.

General comments from the students suggest that the combination of the resilience framework, especially the community resilience dimensions, and the Michigan Civil Rights Commission report documenting historic and structuralized racism in Flint, enabled students to reflect on critical aspects of the Flint water crisis that would not have been possible in a purely technical evaluation of the water treatment and distribution system. Example student comments are provided below.

> *"First, if we consider implicit bias and the nature of it we can assume that if we see implicit bias on an individual level we can then assume it will be on a systemic level as well because those individuals will be one of those who created the system. However, this is hard to combat because it is imprecise and it is different depending on each situation. In our specific situation and similar ones, we can see how in many ways, our laws have not yet caught up with this framing either. Time and time again we have seen the courts struggle to find a racist behind the curtain, struggling with the concept of disparate impact. But we know it does have an effect because of how it effected peoples' lives in this scenario."*

> *"In the United States structural racialization has been placed into every institution in order to hold African Americans back from when slavery was abolished. The report goes into detail about US history and how the country has managed to create white and black neighborhoods through redlining, refusing to give African Americans home loans in certain areas, denying them a lot of jobs, and many other factors. The fact that public schools are funded by a neighborhoods property values also created worse schools in black neighborhoods, which have low property value, also held black people stagnant in terms of success and fueled the school to prison pipeline. The citizens of Flint likely knew all this about American history because it has been their reality for all their lives. The US is a system of so many different institutions and even though there may not have been intent in harming the community, the "structural racialization" was very evident."*

> *"To say that the United States in still battling with 'Structural racialization/Institutional racism/systemic racism' is not accurate. These [laws] among others-- such as the 14th amendment to the US constitution in 1868, 15th amendment in 1870 and new protection legislation in the 20 and 21st century, proves congressional and federal efforts to amend harm and allow rights given back to people of colour when it was taken away from them 200 years ago. This definition is in nature, contradictory to 'Institutional racism' that media advocates, creating division in the country today. To say, according to the Commission report, that the consequences of systemic racism from the 19th century can still hurt communities of colour (this should include Caucasians if we take the word colour in its literal meaning: pigment of skin) is a more accurate depiction."*

Table 5. Examples of student responses mapped to the resilience matrix model

	ROBUSTNESS	RESOURCEFULNESS	RAPIDITY
TECHNICAL	"As the years went by, and the Civil Rights Laws were passed, the deeply rooted structural racialization remained and echoed in present day Flint. Areas of Genesee County that were cheapest to live in, are those communities that had terribly maintained infrastructure."	"Flint did not have adequate monitoring methods that could test for contaminants at the end user level of the system. The City did not employ staff that could properly assess the level of risk of switching water sources as a result of lack of desirability of living in Flint due to the legacy of racism."	
ORGANIZATIONAL	"People and wealth left the city supported by racialized government policies, and formed separate political entities for reasons that may not have been racist, but were certainly racialized." "Current organizational policies are extensions of those same overtly racist policies of the past. Although Jim Crow laws are technically "off the books", their impact to organizational policies are the foundation of today's policies, practices, and most notably, culture." "On the organizational sides of things, the Emergency Planner took precedence over the local community government. This created a situation where the already silent residents lost what little voice they did have." "It's clear from the history outlined in the report that the system which enabled voices of local politicians and residents to be ignored in 2014 began forming all the way back in the second half of the 20th century." "People and wealth left the city supported by racialized government policies, and formed separate political entities for reasons that may not have been racist, but were certainly racialized."	"Most importantly, governance did not heed their complaints and concerns when receiving multiple reports from the community of tainted water." "While there were community meetings, the voices of those effected really were not heard in a way where they were allowed to be part of the decision-making process of the emergency management system."	"Between the location of power and financial restrictions, the perfect storm was brewing where the resources to deal with something of this magnitude were non-existent. With the lack of resources, this meant the timing to get to a solution would be delayed indefinitely without outside influence."

	ROBUSTNESS	RESOURCEFULNESS	RAPIDITY
SOCIAL	"Flint should have been more diversified socio-economically present day, however the planning and neighborhood designs were still very pre-Civil Rights condition. It has been shown that communities with diverse socio-economic backgrounds are more resilient than those who lack it." "First and foremost, it influenced the demographics of Flint making the residents primarily African-American, immigrants, and or poor. This impacted the power of their vote, their political voice or clout, and ultimately their health. It was only through the communities persistence and resistance to stay quiet about the problems they were facing that change occurred. It took over a year because of who they were-poor, less educated, and mostly non-white." "Overall, the discriminatory policies of yesterday created a situation and community that was not prepared to handle any sort of a crisis."	"Structural racism impacts the social characteristics of community resilience in a positive way. The community had a feeling of solidarity to come to each other's aid and work together to combat injustice. The lack of trust for leadership resulted in relying on individuals and neighbors for action"..	
ECONOMIC	"However, lack of funding, lack of jobs, lack of economic activity lead to the decision 200 years later with phenomenal consequences to health, justice and trust." "Because BIPOC were prevented same employment and housing opportunities in the past negatively impacted their representation in organizations that made decisions contributing to the crisis." "The Tiebout model of economic competition was extended to utilities. The way this model is explained in the report is somewhat perverse. It describes utilities, some of which - like water and sanitation - are considered basic human rights, as being a product that those willing (and able) to pay for can access at higher quality in higher tax districts. At the same time, black families were disproportionately excluded from these areas, even if they could afford it, because of bias in obtaining a mortgage or even getting an offer on a house accepted."	"Due to history, there may have not been enough investors to generate income for the city." "Major industries who offer jobs may be further away from this community (residues from segregation)." "Once again when basic human rights such as clean water are violated it is more likely for these rights to never be infringed on to begin with if the community has more wealth."	"State economic interests delayed recovery effort. Relied on "charity" and then inefficient provision of bottled water."

"The 2017 Report of the Michigan Civil Rights Commission, "The Flint Water Crisis: Systemic Racism Through the Lens of Flint" was illuminating, disheartening, and in many ways surprising. (Which at my age should not happen)."

Beyond issues of environmental justice and community health, this approach is recommended to enable students in many disciplines to examine the roles of racial and economic justice in the resilience of any public infrastructure disrupted by extreme events – a topic of increasing importance for civil and environmental engineers.

Potential: Environmental Justice Mapping

Environmental justice issues might be particularly evident using quantitative data shown on maps, although there are also limitations in these approaches [37]. There are a number of different EJ mapping tools; three were compared by Kuruppuarachchi [38]: EJSCREEN, CalEnviroScreen, and EJ Atlas. For example, the U.S. Environmental Protection Agency's EJSCREEN Environmental Justice Mapping and Screening Tool [39] maps eleven environmental indicators (summarized in Table 6) and six demographic indicators (low-income, minority, less than high school education, linguistic isolation, individuals under age 5, individuals over age 64). A combined demographic index (the average of percent minority and percent low income) can also be mapped. This information goes down to a block group level (typically 600-3000 people) to show localized effects. This can be used by students to explore the area around their campus and hometowns across the U.S. The EJSCREEN data was most recently updated in 2019. It is somewhat surprising that these EJ mapping tools have not gotten more attention in environmental engineering education (i.e., no mentions in ASEE annual conference papers based on the PEER search).

Table 6. Comparison of key elements in the US EPA EJSCREEN and CalEnviro Screen

Course	Indicator in EJ Screen [39]	CalEnviro Screen2.0 [41]
Air pollution	PM2.5 Ozone Diesel particulate matter Air toxics cancer risk Air toxics respiratory hazard index	PM2.5 Ozone Diesel particulate matter
Hazardous & industrial waste / remediation	National Priorities List site proximity Hazardous waste Treatment, Storage, Disposal Facilities proximity Risk Management Plan (RMP) facility proximity	Cleanup sites Haz waste sites / facilities Toxic release from facilities Solid waste sites / facilities
Water / Wastewater treatment	Toxicity-weighted wastewater discharges	Drinking water contaminants
Transportation	Traffic proximity and volume	Traffic proximity and volume
Housing	Percentage houses built before 1960 as indicator of potential exposure to lead paint	
Hydrology		Pesticide use Groundwater threats Impaired water bodies

Case studies applying EJSCREEN have been published. For example, Bodenreider et al. [40] determined that "low-income communities of color experience disproportionate exposure to chemical hazards mobilized by floods" in Houston, Texas.

A similar tool to EJSCREEN is CalEnviroScreen 3.0 (updated June 2018 [41]). In this program twenty indicators are combined into four sub-scores (pollution burden: exposures based on seven factors; pollution burden: environmental effects based on five factors; sensitive populations based on three factors; socioeconomic indicators based on five factors) from which a single CalEnviroScreen score (up to 100) is computed. While many of the twelve indicators for pollution burden are similar to EJSCREEN, some are different (e.g. solid waste sites, impaired water bodies). The eight population characteristics selected differ fairly significantly from those in EJSCREEN. A comparison of the two systems and discussion of these differences might make an interesting lesson, particularly for institutions in California where a localized analysis near the university could be conducted.

The global EJ Atlas [42] takes a quite different approach. It maps "social conflict around environmental issues" in ten main categories: nuclear, mining, waste management, biomass and land conflicts, fossil fuels and climate justice/energy, water management, infrastructure and bit environment, tourism recreation, biodiversity conservation conflicts, and industrial and utilities conflicts. Different filters can be applied to the global map to identify sites within each of the ten categories, additional "types" (e.g. incinerator, e-waste, dams), success level, population type (urban, semi-urban, rural), and other characteristics. At each location, the background on the source of conflict and other information are provided. Thus, this atlas might allow students to select case studies for individual or group projects that fit topics appropriate to a range of environmental / civil engineering courses. For example, a topic filter on interbasin water transfers / transboundary water conflicts could identify cases appropriate for a hydrology course and the topic filter on oil and gas refining could identify cases applicable in environmental engineering courses focused on energy issues.

Summary and Conclusions

In order to realize a more just and sustainable future, engineering educators have a responsibility to teach students about the social dimensions and impacts of engineering. Rather than turning a blind eye and claiming 'unfortunate and unforeseen' negative impacts, engineers should be mindful of the interconnected systems that are impacted by engineering. The complexity of the real world poses a host of wicked problems, with many including environmental justice issues. Engineering students should be prepared to face these situations. This paper includes three examples of ways to raise students' awareness of EJ issues, in courses designed for first-year students through graduate students. These teaching models span from interventions aimed at increasing student awareness (lower levels of Bloom's taxonomy) to strategies to deconstruct EJ issues to design more equitable systems. The evidence of impact from these example presented in this paper is limited; future work should conduct longitudinal analysis, particularly of the impact of the first year course. Qualitative methods such as open ended survey items or individual interviews could explore if and how these EJ teaching approaches were impactful.

Each faculty member is encouraged to creatively integrate EJ topics into their courses. While this individual action is preferable to no action, even more impactful would be a curriculum-wide plan for EJ integration. A model for this idea is the University of San Diego engineering program that is working to educate 'changemaking engineers' with expertise related to social justice, sustainability, and humanitarian issues [43]. This curriculum-integrated approach has also been advocated for engineering ethics education [44, 45]. Taking these actions would increase the abilities of future environmental engineers to successfully partner with communities and other professionals to realize more just and equitable outcomes.

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