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Diversity and Inclusion Lessons that Support the Traditional Civil Engineering Curriculum

Dr. Pamela K. Judge, Roger Williams University

Dr. Pamela K. Judge is an Assistant Professor of Engineering at Roger Williams University in Bristol, Rhode Island. Her research interests include geotechnical engineering, coastal protection, equity and social justice in civil engineering, and STEM communication. Dr. Judge is in her third year of teaching at RWU. Prior to joining RWU, Dr. Judge earned a BS in Geological Engineering from the Colorado School of Mines, a MS in Civil Engineering from University of California Berkeley, and a PhD in Civil Engineering from the University of Massachusetts Amherst. Dr. Judge worked as a practicing civil engineering in the Washington DC area for six years. She is both a licensed professional engineer (PE) and professional geologist (PG).

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Abstract

This paper acts as a toolbox for civil engineering educators trying to increase diversity and inclusion lessons in their classrooms. The tools presented in this paper ensure that the rigorous technical components of civil engineering education are maintained. Specifically, this paper presents a series of case studies that highlight diversity and inclusion while simultaneously providing traditional civil engineering course content. This paper also suggests several teaching interventions (both general and case specific) and directly maps out the interventions to ABET learning outcomes. A Transportation Engineering course was used as a pilot initiative by implementing the respective case study. The learning outcomes of the pilot initiative were assessed both with regard to diversity and inclusion lessons and ABET learning outcomes. Civil engineering educators can review the findings of this paper to determine which case study and/or teaching intervention best supports their course or program needs.

1. Introduction

This paper summarizes three cases which each address diversity and inclusion while directly supporting traditional course content within the civil engineering curriculum. The cases identified were: Flint Water Crisis (Environmental Engineering), Robert Moses & The Southern State Parkway's Bridges (Transportation Engineering), and Hurricane Katrina Levee Failures (Geotechnical Engineering). The paper also suggests teaching interventions and directly maps out the content in each case study as it pertains to ABET outcomes and traditional civil engineering course subject matter. A select case and teaching intervention were implemented during a pilot initiative within the Roger Williams University Spring 2021 Transportation Engineering course. Assessment of student learning during the pilot initiative and observations regarding the success and limitations of this approach within the individual classrooms and broader engineering program are presented.

2. Background

Concerns of racism, and its adverse impact on higher education and student success, is a pressing topic facing engineering undergraduate education. The following background briefly summarizes the current state of race in higher education. It then describes the Roger Williams University Diversity and Inclusion Faculty Fellows (DIF) Program.

2.1. Race in Higher Education

Black Lives Matter protests [1], hate crimes, and discrimination against students and faculty of color [2] are in the news on a frequent basis. This increases awareness of matters of diversity and inclusion within higher education. These concerns are greatly the result of preexisting structural racism that exist within higher education with regard to enrollment, hiring, funding, publications, course content, etc. People of color in higher education often describe experiencing feelings of marginalization and difference with regard to their race; this matter is further exacerbated for women of color who also feel marginalized by their gender [3].

Regarding structural racism, a white (often male) professor may be unaware that opportunities in engineering had been historically constrained to a select few [4]. Structural racism draws close attention to the historical, cultural, and social aspects of race in our society [4]. Further, [5] coined the term *education violence* to describe how marginalized people both in and outside of formal systems of schooling have had their lives limited and ended due to white supremacy. According to [5], education violence cannot be defined narrowly as personal harm, intimidation, or death at the hands of another person. While higher education institutions operate through people, education violence functions not solely in interpersonal relations but also at the structural, cultural, and direct levels.

Some engineering faculty may believe their work is inherently computational and analytical; therefore, engineering is immune to issues of racism and inequity. Mathematics, some believe, is inherently objective and not subject to personal opinions and biases. However, issues of structural racism and educational violence touch on all elements of higher education. In fact, many issues of discrimination and inequity are exacerbated in the science, technology, engineering, and math (STEM) fields. Engineering education in the United States has been accused of favoring white men at the exclusion of those traditionally underrepresented in engineering. However, contrary to the culturally responsive literature addressing approaches to "colorblindness," engineering faculty believe they should treat all students equally [4]. Engineering professors are experts in their technical fields, but these individuals have generally lacked both significant pedagogical training and a background in educational theory, including an understanding of inclusive teaching practices [4]. Further, according to [4], "Even when opportunities for faculty to learn about research-supported educational strategies arise through workshops, webinars, and presentations, various forms of resistance remain intact. These include lack of resources, faculty skepticism toward alternative teaching strategies, faculty trepidation of negative teaching evaluations and engineering faculty mistrust in educational experts from outside the engineering disciplines."

Today, higher education (and specifically engineering programs) must rise to the challenge and increase awareness of issues regarding diversity; students must be informed citizens. Rapid changes in technology, changing racial and ethnic demographics, national security, and globalization have all fueled the push to increase and diversify the science and engineering workforce [6]. Further, expanding racial (and gender) representation of engineering faculty has become a top priority in many engineering colleges and departments across the country. Despite the best intentions, many organizations have failed to reflect societal demographics within their faculty ranks. Techniques and strategies exist to recruit candidates from traditionally underrepresented groups, yet the full participation of these groups has not been achieved [6]. It is clear that the engineering programs within higher education must improve their teaching approaches to address issues of diversity within the classroom. Further, affirmative action and similar initiatives intended to increase enrollment of ethnic minority students, and hire and promote ethnic minority professors, while showing small improvements, is not happening at nearly the pace required to keep up with the demands of the modern economy. Concerns of structural racism and educational violence within undergraduate engineering education is not adequately addressed.

2.2. DIF Program

This begs the question, "What can be done *today,* and *at minimal cost,* to improve diversity and inclusion in the engineering classroom?" Such was the initiative for the author to participate in the Roger Williams University Diversity and Inclusion Faculty Fellows Program (DIF). DIF is a peer-mentoring community of practice that recognizes, fosters and supports professional growth around diversity, social justice and inclusion in the classroom. The program is a space for professional growth where faculty can openly discuss questions around pedagogies of inclusion, and develop and refine practices for centering equity-minded and inclusive practices in courses across all disciplines. The program intends to better align faculty and their classrooms with the current needs of students and the broader community with regard to diversity and inclusion. Ultimately, faculty in this community examine best practice literature and engage in workshops with an aim to develop pedagogical philosophies and approaches to teaching that decenter dominant identities, challenge institutional violence, and minimize hostile environments for minority students [7]. Diversity & Inclusion Fellows (DIFs) engage in readings and workshops that help them to interrogate their own pedagogical philosophies related to inclusive pedagogy and develop and refine strategies and interventions for creating more inclusive classrooms. Faculty participants then implement these practices in one of their courses in the following semester. Meetings take place once or twice a month, and led by two experienced DIF faculty members who serve as Lead Fellows.

Eight DIFs were selected for the 2020 – 2021 academic year, including a librarian and seven instructors at varying stages of their professorial careers. The DIFs included representatives from across a wide range of disciplines including two representatives from engineering (one being the author of this paper), and one from each of the following disciplines: anthropology/sociology, architecture/art, communication, creative writing, history, and legal writing.

3. Challenges to Modifying the Existing Engineering Curriculum

Preliminary DIF meetings brought to light an important issue with regard to achieving the DIF program's purpose of "social justice and inclusion in the classroom." Specifically, it became apparent during early discussions that the civil engineering representatives believed there was considerably less room to adjust curriculum and teaching methods to include issues of diversity in the classroom and to teach in a manner that was more equitable to minority students, relative to that of liberal arts programs. This is the result of five factors:

1. Civil engineering, and engineering undergraduate education in general, is driven greatly by the ABET accreditation requirements for engineering programs. Further, within each engineering course a threshold of learning outcomes must be achieved an objectively verifiable way. There is little, if any, time to add additional topics that are not specific to a learning outcome.

2. Engineering students are required to take a heavy credit load (relative to many liberal arts programs) that leaves little room for additional electives.

3. The undergraduate education is highly geared towards preparing students to take the Fundamentals of Engineering (FE) exam which is inherently computational, leaving little opportunity to vary teaching methods and topics.

4. Engineering faculty have many responsibilities, including, but not limited to: teaching a heavy course load, laboratory research, writing publications, applying for funding, attending conferences, managing laboratory materials and safety, mentoring students, networking with industry, and professional development. Therefore, professors' time is often limited, and professors may not see the value in adjusting a preexisting course.

5. Engineering education is often based on precedent; it is slow to accept change, especially relative to liberal arts programs.

It is clear that any attempt to reinvent the existing traditional engineering educational structure (to include additional lessons on diversity and inclusion) is very challenging. In light of this, it became the author's goal to develop a toolbox by which engineering educators could create flexible, yet effective, means of increasing diversity and inclusion lessons within the traditional civil engineering education.

4. Literature Review

The most straightforward means of addressing diversity and inclusion within the traditional civil engineering curriculum is through the use of case studies. Case studies are a well-established means of exploring a situation in detail, learning from past mistakes, and creating simple yet effective assessments of students' understanding. Ethics, for example, is often taught in civil engineering through the use of case studies. Further, case studies offer an opportunity for interdisciplinary discussions centered on human dignity and justice goals [8] and likewise develop empathy for the users impacted by the project. Empathy is increasingly being recognized for the central role it may play in connecting crucial inter- and intrapersonal skills with enhanced abilities to understand and productively work in multidisciplinary environments with diverse stakeholder groups [9]. Finally, some professors may not feel comfortable directly discussing race and related topics within an otherwise technical classroom environment; case studies allow the emphasis to be taken off of the professor directly, and instead placed on the evidence and conclusions of the case. Both students and faculty may feel more comfortable thinking, speaking, and/or writing freely when there is established and structured content on which to frame the discussion.

A focus was placed on identifying well established civil engineering case problems that had an element of race and/or inclusion which impacted the outcome of the overall civil engineering project. The literature review centered on identifying three key civil engineering cases, each of which supports one of three courses common to undergraduate civil engineering education. The three cases identified were: *Flint Michigan Water Crisis* (Environmental Engineering), *Robert*

Moses & The Southern State Parkway's Bridges (Transportation Engineering), and *Hurricane Katrina Levee Failures* (Geotechnical Engineering). The following literature review includes a summary of the respective case with specific regard to demographic and socioeconomic issues. Each case concludes with a brief list of respective engineering course topics which are highlighted by the respective case. The following summaries are very brief and are provided for the sake of understanding this exercise. The reader is encouraged to refer to the literature for more detailed information regarding the technical aspects of the civil engineering projects for each of the respective cases.

4.1. Environmental Engineering: Flint Michigan Water Crisis

In May 2014, some Flint Michigan residents complained about the smell and color of the water, after a cost-saving switch to a new source with poorer raw water quality. Treatment of the raw water was also switched to an older, previously off-line plant that was brought online very quickly to treat the new water source without proper testing or addition of corrosion control to prevent corrosion in the older lead pipe distribution system. Residents (mostly non-white working-class community) began complaining about water discoloration and hair loss etc., although their concerns were greatly ignored. By October, General Motors said it would stop using Flint River water, fearing corrosion in its machines [10]. City and state officials denied for months that there was a serious problem. Further investigation revealed huge amounts of lead in the drinking water was resulting from the lack of corrosion control addition at the treatment plant. The city switched back to its original water supply late 2015, but it was too late to reverse the damage to the pipes. High lead levels in blood can have significant negative impacts to children and expecting mothers; it can cause learning disabilities, behavioral problems and mental retardation [10].

Lead seepage into the drinking water in Flint, Michigan, has caused a massive public health crisis and prompted President Obama to declare a federal state of emergency there [10]. Flint failed to properly treat the water and dangerous levels of lead leached from old pipes, setting up a public health crisis that has endangered thousands of children and affected every resident, many of whom had to drink bottled water for long periods of time. Many residents still rely on bottled water [11].

Flint is a majority-black city where 40 percent of people live in poverty [10]. Flint has experienced extreme population loss due to factors like the closure of automobile production facilities and the movement of residents, particularly white, middle-class residents, to the surrounding suburbs. At Flint's peak in the 1960s, the city was home to nearly 200,000 people; as of 2016 it was home to 98,000 [12]. As a result, there are fewer residents to pay property and income taxes, fewer people available shopping at local businesses, and likewise less tax revenue, and more vacant structures which, in turn, reduces property values. This creates a downward spiral of furthered reduced tax revenues [12].

The Flint Michigan water crisis highlights several topics commonly covered in an undergraduate Environmental Engineering course, including: mechanisms of environmental degradation, water supply and control, water pollution and treatment, and interrelationships between humans and the environment.

4.2. Transportation Engineering: Robert Moses & The Southern State Parkway's Bridges

Robert Moses ordered his engineers to build the bridges over the Southern State parkway to a low clearance height [13]; in lowering the height of the bridges, buses from New York City were kept away from Jones Beach because the buses were too tall to clear the overpasses. This, in turn, prevented low-income minority (black and Puerto Rican) residents of the city from accessing the public beach; Moses openly despised these low-income minority populations [13]. The presumption that the lowering of the bridges was a direct attempt to keep low-income minority persons away from the beach may be an over simplification of the situation. A more complete story highlights that the road was a designated as a *parkway* (as opposed to a *highway*), and therefore commercial traffic (trucks and buses alike) were excluded, as was the norm for US parkways. Parkways were intended to act as a respite from the busy city and banning big, noisy commercial vehicles was seen as an essential element to the aesthetics of the parkway. Directly intentional or not, the end result was the same: low-income minority residents (who could not afford a personal vehicle at the time) were unable to access the public beach. Further, even an attempt to revise policies to potentially allow bus access (while continuing to prohibit commercial trucks) would have proved ineffective. Those preexisting low clearance bridges were made of concrete and stone which are very difficult and expensive to demolish and replace [13].

Transportation mobility is critical for livable communities and facilitates social engagement, communication and information, civic participation, employment, housing, health and community, respect and inclusion. Vulnerable populations (such as older adults, persons of low income, low socioeconomic status, racial and ethnic minorities, and individuals with disabilities) are at increased risk for transportation disadvantage and may experience an increase in barriers related to overall quality of life and well-being due to these compounding factors [14].

The case of Robert Moses and the Southern State Parkway's Bridges presents several topics common in an undergraduate course on transportation engineering, including: clearance height of overpass structure above a roadway, geometric design considerations, vehicle classification, construction materials, resource allocations, user input, design life, and human behavior factors.

4.3. Geotechnical Engineering: Hurricane Katrina Levee Failures

In late August 2005, Hurricane Katrina (Category 4 level prior to making landfall) imposed unusually severe wind loads, storm surges, and waves on the New Orleans region and its flood protection systems canals [15]. Hurricane Katrina did horrific damage to Louisiana and the Mississippi Gulf Coast, killing more than a thousand people and destroying billions of dollars of property [16]. The Lower Ninth Ward of New Orleans was one of the hardest hit communities in the New Orleans metropolitan region. There is strong evidence for the massive overtopping of the levees along the northeast edge of the St. Bernard Parish/Ninth Ward levee system [15].

The primary levee system for the Lower Ninth Ward of New Orleans and neighboring St. Bernard Parish consisted largely of earthen levees constructed of relatively poor materials. The floodwaters from the severe overtopping then flowed across the open, undeveloped swampland to the southwest and overtopped a secondary set of levees [15].

As of 2004, New Orleans' population was 20.0% white and 67.9% black. Additionally, New Orleans has a poverty rate of 38%-among the highest in the United States. The 2000 census revealed that 27% of New Orleans households, amounting to approximately 120,000 people, were without privately owned transportation. These statistics alone go far to explain why tens of thousands of the 500,000 residents of New Orleans did not evacuate [16]. It is important to remember, when designing for natural disaster prevention, that some people are much more vulnerable than others in the face of a natural disaster. Rich people tend to occupy higher land, leaving the poor and working-class land more vulnerable to flooding and environmental pestilence. In New Orleans topographic gradients doubled as class and race gradients, and as the Katrina evacuation so tragically demonstrated, the better off had cars to get out, credit cards and bank accounts for emergency hotels and supplies, their immediate families likely had resources to support their evacuation, and the wealthier also had the insurance policies for rebuilding [16].

The Hurricane Katrina Levee Failure case clearly addresses several topics relevant to an undergraduate geotechnical engineering class, including: soil classification, retaining wall systems, earthen embankments, topography, groundwater conditions, wetlands, and scour.

5. Teaching Interventions

The following discussion suggests several teaching interventions to increase diversity and inclusion topics in the civil engineering classroom. The discussion starts with a summary of several useful general strategies to help engineering educators teach topics of diversity and inclusion; these strategies encourage students to participate in the discussion in an active and constructive manner. The list of general strategies was produced as a result of participating in the DIF program.

This discussion then provides suggested teaching intervention specific to each of the cases and respective engineering course. These case specific interventions include: an *ethics debate* in environmental engineering, a *design project* for transportation engineering, and a *research paper* for geotechnical engineering. By no means is this intended to be prescriptive or a fully comprehensive list; there are many additional case studies to consider, and many other methods of teaching and assessing learning beyond those described herein. The instructor can modify or transpose the teaching interventions amongst the classes and cases. The teaching interventions described herein simply act as a set of tools for engineering instructors to consider within their civil engineering courses, while simultaneously addressing ABET learning outcomes.

There is a common element amongst the case specific interventions suggested herein: they each involve more than simply lecturing. Using teaching interventions beyond lecturing accomplishes three diversity and inclusion goals. First, it helps underrepresented students who may be taking the class. As [4] indicates: Despite extensive research that has demonstrated the ineffectiveness of lecturing as a primary teaching strategy the traditional paradigm has dominated engineering education since its inception. Evidence-based research suggests that revising engineering educational practices can positively influence the learning, success, and retention of underrepresented students. Second, case based learning, in particular, is an effective means of having a student remember the importance of the topic and be motivated to fix it. As [14] mentions: “If you can put a human face on the problem, maybe people will be more interested in solving it.” And, third, it enables students to address a range of “soft skills” such as communicating to a wide audience, coordinating work within a team, evaluating ethics, and considering the broader societal implications of the project.

5.1. Useful Strategies

All students deserve an opportunity to fully participate in the diversity and inclusion activities within a civil engineering classroom. However, many engineering students are introverted; they may feel uncomfortable speaking aloud regarding a topic that is subjective or controversial. Further, students require adequate time to absorb the material and respond in a mindful manner. The following summarizes five generally useful strategies for an engineering educator to implement when planning their diversity and inclusion lesson for their respective course. These strategies help ensure that that each student feels their opinion is heard and respected.

1. Provide literature regarding the case as a reading assignment several days ahead of any in-class activity. This allows students an opportunity to read the case over at their own pace, take notes, and collect their own personal thoughts. It also allows more time during the formal lecture session for discussion or collaboration with their peers.

2. Many engineering students may not belong to a racial minority; they may feel they do not possess any relevant knowledge to contribute. It is important to remind the students that they all come with prior experience they can share. Perhaps it is an experience with regard to their gender, physical disability, or mental health challenges. Or perhaps they witnessed a friend enduring a difficult experience. Emphasize that we all bring a unique prospective that is valuable to the conversation.

3. If there is a student that is a racial minority in the classroom: do not single that student out. It is not the minority student's responsibility to do "extra work" on the behalf of the other (racial majority) students. A minority student is welcome to share as much (or as little) as they are comfortable. Likewise, the minority student must not be tokenized.

4. Be sure that the topic of "race" is directly discussed in its own right. It is common for students (and even instructors) to revert to centering the discussion on "financial status." While there are overlaps between race and financial status, they are not the same issue and should not be used interchangeably. If anyone feels uncomfortable directly speaking about race; it may help to refer to the case.

5. Students value an opportunity to reflect on what they have learned, and students are much more likely to open up about their thoughts when the reflection is anonymous. However, an anonymous reflection creates a challenge to grade as an assignment. Therefore, consider creating an opportunity for reflection that is not graded. Some options include: (1) an anonymous Google form or other electronic shared platform; (2) free writing journal entry that is not submitted; or (3) an extra credit opportunity to the whole class for participation points.

5.2. Environmental: Flint Water Crisis – Ethics Debate

The Flint water crisis is clearly a matter of environmental injustice. This creates an opportunity to discuss the situation in the terms of an ethical debate. First, students should read over the timeline presented by [10] as a homework assignment to prepare themselves for a subsequent in-classroom debate. At the start of the exercise, the instructor should clearly define the current American Society of Civil Engineers (ASCE) code of ethics. Students can take on one of the roles of the various stakeholders, and then participate in a role-playing exercise. Probing questions include, but are not limited to, the following:

- Was the lead poisoning intentional?
- Did the engineers do anything unethical?
- What role, if any, did demographics and socioeconomics play in this case?
- What should have been done to improve the water quality?

Students do not necessarily have to come to a singularly correct solution (or even a unanimous solution) regarding future improvements. The main purpose of this exercise is to get students thinking about the broader social implications and ethical outcomes of their actions.

The instructor should remind students that Flint is not alone in having a water system that is in need of replacement. Many European and older American cities have infrastructure that is at (or nearing) the end of its lifespan. This is especially true in large U.S. cities in the Northeast and Midwest, where over 60% of the water infrastructure was built prior to 1930 [12]. Therefore, rather than think of the Flint water crisis as one unfortunate event that was entirely preventable with corrosion controls, we should think of it as a warning to other cities in the U.S. [12].

5.3. Transportation: Southern State Parkway's Bridges – Design Project

The Southern State Parkway's Bridges case touches on issues of aesthetics and resiliency within engineering design. This creates an excellent opportunity for a team-based design project. Students can work in teams to design a *better* parkway system. Students are faced with the challenge: Design an aesthetic parkway that allows for public transportation (i.e., busses) while minimizing commercial trucking. As a design project, students can prepare drawings, provide cost estimates, layout construction schedules, etc. The civil engineering instructor should emphasize the importance of keeping the various stakeholders of a project in mind throughout the course of a design; the final design must be inclusive for all potential users. Further, the engineers should strive to create designs today that are flexible, resilient, and can anticipate the needs of a changing planet and society. This design approach will create a better, holistic, and more cost-effective design in the long term.

5.4. Geotechnical: Katrina Levee Failures – Research Paper

The Hurricane Katrina Levee Failure case highlights the challenges encountered when designing natural disaster mitigation infrastructure for a community which demonstrates varying degrees of vulnerability. A "one size fits all" design may not suit all persons because the individuals do not necessarily demonstrate the same level of need or risk with regard to health, safety, and property damage. Recall, the case mentioned flood protection of the Lower Ninth Ward was predominantly earthen levees constructed of relatively poor materials. Likewise, design challenges are further exacerbated when investments in design, construction, and maintenance are adversely impacted based on a community's lack of financial resources and/or political leverage. It begs the question: "Should the standard of design and construction be *higher* in more vulnerable areas to counteract respectively high levels of risk faced by the vulnerable community?"

This suggested teaching intervention is particularly impactful for students if it is executed as a place-based exercise; students feel invested in the outcome. Students are challenged to determine the best ways to design a natural disaster mitigation strategy in light of varying levels of vulnerability, and to present their findings in the form of a research paper. Specifically, students should consider a potential natural disaster in a major city of interest, such the state capital or major metropolitan area close to their campus or place of birth. While the Hurricane Katrina Levee Failure case focused on coastal flooding, there are many other potential natural disasters to consider for the research paper including: earthquakes, landslides, dam failures, sinkholes, groundwater contamination, etc. The assignment should require the use census data to map out locations within the city that may be of higher or lower levels of vulnerability. Relevant demographic information may include: age, income, race, level of education, gender, etc. Finally, students should research engineering alternatives to overcome the higher level of risk associated with the highly vulnerable areas. Through this activity, each student develops an appreciation for the variety of vulnerabilities that may exist within a city or community. They should also gain an understanding that the final design must be safe for all members of the community, even under stressed conditions such as a natural disaster.

6. Mapping to ABET

The following discussion summarizes the manner in which each case study and suggested case specific teaching intervention is mapped to the respective ABET learning outcomes [17]. The three cases, and their respective teaching interventions, combine to touch on all seven of the ABET learning outcomes.

A discussion on the ethical implications of the Flint Water Crisis clearly addresses an "ability to recognize ethical and professional responsibilities" as well as considering "the impact of engineering solutions in … societal context" (Learning Outcome 4). If the discussion is structured in the form of a debate (students role playing as the various stakeholders), it also acts to support "an ability to communicate effectively with a range of audiences" (Learning Outcome 3).

In reviewing the Southern State Parkway's Bridges case, and identifying the subsequent engineering challenges, students develop "an ability to identify… engineering problems by applying principles of engineering, science, and mathematics" (Learning Outcome 1). By developing an assignment around designing a better parkway, students develop "an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors" (Learning Outcome 2). A considerable amount of time required in preparing drawings, cost estimates, and schedules. Therefore, it is recommended that this project be performed in teams. Likewise, students develop "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" (Learning Outcome 5).

As students learn about the Hurricane Katrina Levee Failure, and research their own communities' vulnerability, they are developing an ability to "analyze and interpret data, and use engineering judgment to draw conclusions" (Learning Outcome 6). Finally, as students write a research paper, and consider how they might modify engineering designs to account for varying degrees of vulnerability, they are gaining "an ability to acquire and apply new knowledge as needed, using appropriate learning strategies." (Learning Outcome 7).

7. Pilot Initiative

The mission of DIF is to offer faculty participants an opportunity to implement best diversity and inclusion practices into one of their courses. Therefore, a pilot initiative was undertaken by the author for the Spring 2021 semester. The goal was to directly address race in the Transportation Engineering course by introducing the *Robert Moses and the Southern State Parkway's Bridges*. The success of the students learning, both with regard to diversity and inclusion lessons and ABET learning outcomes, were assessed.

7.1. Methods

The initial plan consisted of introducing the transportation case as a design project. However, adjustments to mentoring senior design teams at the program coordination level caused the transportation semester project to be reallocated to a different project scope. This was in order to satisfy a prior commitment to an existing client. Therefore, the decision was made to still incorporate the *Robert Moses and the Southern State Parkway's Bridges* case, although now in the form of an ethics debate. Still, students were encouraged to brainstorm how they might improve the design.

Students read over the *Robert Moses and the Southern State Parkway's Bridges* case, as well as the ASCE Code of Ethics, a few days prior to attending lecture. During class the students were randomly assigned a place card for their desk which identified a stakeholder (e.g., the planning office, a bridge engineer, a New York City resident without a car, an owner of a trucking company, etc.) The students then debated the case in the form of a "town hall meeting". They were encouraged to "put themselves in the shoes" of their respective role. They were prompted to consider the project in terms of ethics, service, cost, and safety. Following the role-playing exercise students were encouraged to submit an anonymous survey as a reflection, which highlighted topics addressed in the debate. The students were also asked to quantify how satisfied they were with regard to meeting the corresponding ABET learning outcomes.

7.2. Results

Eleven students were present on the day of the activity, and eleven submitted reflections. Several student responses to the anonymous reflection surveys are provided below:

- **Which part of the current ASCE Code of Ethics is most applicable to the case?**

  All eleven responses referenced: "*CANON 8. Treat All Persons Fairly*"

- **What role, if any, did demographics and socioeconomics play in this case?**

  "It was the primary driving voice as to address the issue at hand as they had to pay the taxes for the parkway, and yet couldn't utilize it."

  "Demographics and socioeconomics played a huge role in this case and were probably the driving factor. With any design, socioeconomics will always play a role because money talks."

  "I think demographics and socioeconomics played a HUGE role in this case. I know it was a different time and blatant racism was prevalent, but no one planning this project even considered that maybe less fortunate people do not have their own cars and may never have one... Moses and the planning committee, did not even consider the fact that it is anyone's right to be able to publicly access this parkway. This all comes down to the fact that a lot of the people with privilege, did (and do) not look at people who are marginalized as worthy."

- **How might you improve the design today?**

  Students suggested a range of design modifications including lowering the road, raising the bridge, removing the bridge, designating historical landmarks, building a tunnel, and implementing parkway tolls.

- **In what way, if any, has analyzing this case encouraged you to behave in an ethical manner?**

  "You will lose credibility as an engineer if you act selfishly or with individualistic intent in design."

  "Everybody is affected by the decisions engineers make and it is very important to consider the input of all stakeholders."

  "I can hear as many opinions as I possibly can… to see what I can actually do about their concerns."

- **In what way, if any, has analyzing this case encouraged you to consider the impact of race and minority and/or low income communities in civil engineering projects?**

  "It is important to consider all people."

  "…you have to consider how it impacts the minority community."

"It would seem to me that the civil engineer themselves is responsible for being the voice of minorities and low income peoples who otherwise would be ignored."

"This case has made me aware that politics can be involved in civil engineering and that when designing anything, it is important to consider all people."

"Civil engineering directly effects and impacts race and class, and it is so important to consider those things before starting projects of any size. I think we need to talk about these things more because it is so easy to get caught up in our own realities, and some people cannot see outside the scope of their own privilege. This is a big issue due to the fact that systemic racism even impacts who has an easier time becoming highly educated, and that results in a lot of engineers with privilege making decisions for communities that they cannot even relate to. With education comes solutions."

The results of the quantitative responses regarding ABET learning outcomes are provided in Table 1, where a score of 1 represents "strongly disagree" and a score of 5 represents "strongly agree". Eleven students responded.

Table 1: Transportation Engineering ABET Learning Outcome Assessment
1 = Strongly Disagree, 5 = Strongly Agree

ABET Learning Outcome [17]	**Minimum**	**Average**	**Maximum**
Analyzing the case has improved my ability to "recognize ethical and professional responsibilities in engineering situations and make informed judgments" (ABET Learning Outcome 4)	4.0	4.5	5.0
Analyzing the case encouraged me to "consider the impact of engineering solutions in global, economic, environmental, and societal contexts" (ABET Learning Outcome 4)	4.0	4.4	5.0
The ethics debate (role playing exercise) has improved my ability to communicate effectively with a range of audiences. (ABET Learning Outcome 3)	3.0	4.1	5.0

7.3. Key Findings

Several key findings were gained from the pilot initiative. Below is a summary of the strengths of the tools (i.e., cases and teaching interventions):

1. Centering discussions on the case study clearly enabled classroom conversations regarding race in a constructive and effective manner. In fact, the words "race" and "racism" appeared in student reflections. This proves that the discussions did not simply default to "financial status" (which is too often the case in diversity and inclusion work).

2. ABET Learning Outcome 4 (regarding ethics) was clearly met. Further, having students review the ASCE Code of Ethics as part of the ethics debate helped prepare the students for the FE exam.

3. ABET Learning Outcomes 3 (regarding effective communication) was adequately addressed.

4. The diversity and inclusion topics were introduced to the class with minimal additional preparation effort on the behalf on the instructor.

5. No technical coursework (traditional civil engineering calculations and analyses) was removed from the course to create room in the syllabus for the topics of diversity and inclusion.

6. Students felt comfortable sharing their thoughts through both verbal and written means of communication.

7. Students clearly gained an appreciation of the broader socioeconomic impacts that engineering projects have on communities.

8. The case was robust enough, and the teaching interventions flexible enough, that the Transportation Engineering course accommodated a last-minute course adjustment (switching from a design project to an ethics debate.) The case still met expectation: diversity and inclusion lessons were included and ABET learning outcomes were addressed.

9. Students participated in "out of the box" thinking to develop potential design solutions to the engineering challenges posed by the case.

10. Students understood that the case still has relevance today. They realized that it is not enough to simply learn from a prior mistake. Rather, engineers should actively work towards justice within civil engineering project.

It is clear that presenting a specific case within a specific course is feasible with minimal additional preparation on the behalf of an instructor. It is also clear that one or more ABET Learning Outcomes can be readily addressed within a course, with ethics (Learning Outcome 4) being the most directly applicable. However, one considerable challenge was made apparent through this pilot initiative: Presenting all three cases and addressing all seven learning outcomes across an entire engineering program could take a couple semesters, if not years, to fully execute. This holistic level of implementation may warrant considerable coordination on the program level. This is because there is always uncertainty within the nature of engineering academia for several reasons: (1) Courses may (or may not) be offered in a specific semester. (2) Short term adjustments to teaching assignments are often required to cover sabbaticals, medical leaves, retirements, etc. And, (3) there may be preexisting constraints to term projects based on prior program commitments. Therefore, it will take time for all of the infrastructure to be put in place to ensure all three cases and all seven learning outcomes are addressed both directly in the respective courses, and broadly across the civil engineering program. That being said, the cases suggested herein are well established and robust. The teaching interventions are relatively flexible and could be applied to the various cases with relative ease.

8. Conclusion

Concerns of racism, and its adverse impact on higher education and student success, is a pressing topic facing engineering undergraduate education. The most straightforward means of addressing issues of diversity and inclusion within the traditional civil engineering curriculum is through the use of case studies. Case studies are a well-established means of exploring a situation in detail, learning from past mistakes, and creating simple yet effective assessments of students' understanding. The three cases identified (and their respective traditional civil engineering course), were as follows: *Flint Michigan Water Crisis* (Environmental Engineering), *Robert Moses & The Southern State Parkway's Bridges* (Transportation Engineering), and *Hurricane Katrina Levee Failures* (Geotechnical Engineering). As the Roger Williams University pilot initiative assessment indicated, incorporating a case within a traditional engineering classroom created an opportunity to discuss racial injustice while maintaining the academic rigor of the program and addressing ABET learning outcomes.

In summary, this paper presented a series of tools to help civil engineering educators modify their course content and pedagogical methods in a flexible but effective manner. Civil engineering educators can implement the case studies and teaching interventions (both general strategies and case specific learning activities) discussed throughout this paper to determine which case study best supports their course or program needs. In this manner, instructors can seamlessly and efficiently make changes to their individual course content. It is possible to include lessons on diversity and inclusion without sacrificing the quantitative and analytical component necessary to the civil engineering undergraduate education.

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