How Do Students Take up Notions of Environmental Racism in an Engineering Computational Methods Course?

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Abstract.
Engineering departments have begun to prioritize more computational methods in their disciplines. Across engineering schools, computational methods are taught differently, but traditionally without context. In this study, we have revised an introductory engineering computing course such that students take up social, economic, and political contexts as they are introduced to coding and statistics. These contextual elements take three forms. The first is a weekly assignment where students read, reflect, and discuss various equity and justice-themed articles. The second is four weeklong projects over the semester that require a sociotechnical perspective to complete. Lastly, students complete an open-ended final project that requires attention to equity dimensions in each project step. This paper will examine the students' responses to the weekly discussion reading on environmental racism.

In this study, we focus on one week in which students read and reflected on two articles. One was an article from The Atlantic, titled "A New EPA Report Shows that Environmental Racism is Real" (Newkirk II, 2018). The other was an article from Vox titled, "There's a clear fix to helping Black communities fight pollution" (Ramirez, 2021). The majority of students in this study are first-years enrolled in the school of engineering. The study takes place at a medium-sized, private, predominantly white institution in the northeast region of the US. Responses were collected across two years of this sociotechnical engineering revision. This study is not intended to compare the two years but to understand the breadth of ideas and responses students have in response to reading and reflecting on the article. Notably, two class sections of the course were revised in year one of the projects (2021), and all five sections of the course were revised in year two (2022). Each section is taught by a different engineering instructor. This study is not intended to compare students across different sections. Instead, through this qualitative thematic analysis, we attend to the different ways students take up and respond to social, political, and economic dimensions that have to do with the environment.

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Introduction

In engineering education, environmental issues are often discussed without an understanding of environmental racism and environmental justice. Engineering programs are adapting to the increasing concerns about the environment–from cluster hires regarding climate change and sustainability to an increased number of engineering classes within these disciplines. However, while the added attention to environmental concerns is welcome, they do not always include histories or understandings of environmental racism. This history is critical as we teach engineering students to understand the roles engineering 'solutions' played in further disenfranchising historically excluded communities. Learning about environmental racism means understanding "the ways human activity about the non-human world affects people in different ways" that follow practices of institutional racism (Cohen, 2020, p. 688).

> "Environmental hazards are inequitably distributed in the United States, with poor people and people of color bearing a greater share of pollution than richer people and white people" (Cole and Foster, 2000, p. 10).

In this study, we have revised an introductory engineering computation course such that students take up social, economic, and political contexts as they are introduced to coding and statistics. The inclusion of environmental racism in a computational methods course is particularly helpful in making the case to keep quantitative variables such as race & ethnicity and socioeconomic status separate to avoid colorblind analyses. However, there is a need to bring historical insight into the ways that opportunities for wealth accumulation have been disparately provided and challenged in the United States. While the separation of race and socioeconomic status is important to name racist practices, there is still a need for students to grapple with the ways these variables are not independent. As students make computational decisions about what data to collect, analyze, and present, we want them to develop an understanding of the sociopolitical context in which they are making these decisions.

This paper will examine the students' responses to the weekly discussion reading on environmental racism. In addition to this study, this sociotechnical curricular revision has been studied elsewhere, one focusing on the experiences of seven minoritized students' sense of belonging as they learn about engineering as sociotechnical (Ozkan and Andrews, 2022) and another focusing on the student responses to a week on inequities in public transit (Pangan and Andrews, 2022).

Background

Environmental Racism and Environmental Justice

Environmental racism and environmental justice are interrelated terms. Environmental racism refers to the disproportionate harm of environmental hazards on minoritized communities–primarily communities of color (EPA, n.d.). These harms can be physical and impact community health, and they can be economic in that they extract resources without helping residents. Environmental justice encompasses the need to repair these disproportionate harms (Cole and Foster, 2000). Environmental racism and environmental justice are close in definitions, but one signifies the harm and the other signifies the action or orientation to rectify harm. In this paper, we take care to distinguish our use between the two.

Historical Background of the Environmental Justice Movement

We trace a history of the environmental justice movement to emphasize that from the beginning, the environment and racial justice have been one and the same and that their separation was an erasure of that history. The environmental justice movement did not have a singular origin but emerged out of hundreds of local efforts to resist and name disproportionate burdens inflicted by large corporate and government projects. However, through the post-war era, the 1950s, 1960s, and 1970s, several overlapping movements were on the rise–the Civil Rights Movement, the Labor Movement, and the Environmental Movement. The Civil Rights Movement, perhaps the most prominent and intersectional movement at this time, emerged out of the Southern US states. Interestingly, the Civil Rights Movement was largely based in the church, with leaders as ministers–Rev. Dr. Martin Luther King Jr. and Rev. Ralph Abernathy. One point of intersection was the 1982 protests in Warren County, North Carolina against a toxic chemical dump (polychlorinated biphenyls or PCBs) (Cole and Foster, 2000). This protest was led by Warren County church officials and the Rev. Benjamin Davis who was the head of the United Church of Christ's Commission for Racial Justice. In 1987, the United Church of Christ (UCC) Commission for Racial Justice published its landmark report documenting environmental racism, '*Toxic Wastes and Race in the United States.'* In this study, they expose the direct correlation between communities of color and the placement of toxic waste facilities, which sparked many grassroots environmental justice initiatives and government attention. In addition to civil rights leaders, the environmental justice movement also included leaders organizing for Latinx and Chicano rights.

The Civil Rights and Anti-Toxics Movement became complementary and related movements. An anti-toxic movement emerged out of grassroots organization, which at times used scientific and technical information to discredit rhetoric that followed toxic dumping, saying it was not harmful. Organizers in the anti-toxic movements had goals of reducing pollution. While the anti-toxic groups were grassroots they built national networks of scientists, academics, and local activists, which greatly bolstered the movements. The anti-toxic movement worked under a structural understanding of power and economic structures.

> "Anti-toxics activists, through the process of local fights against polluting facilities, came to understand discrete toxic assaults as part of an economic structure in which, as part of the 'natural' functioning of the economy, certain communities would be polluted." (Cole and Foster, 2000 p. 23).

In the 1980s, civil rights leaders worked with the anti-toxics movement to conduct economic analyses through their understanding of structures. In turn, anti-toxics leaders brought in the civil rights activists' racial critiques (Cole and Foster, 2000). Together, these integrations of knowledge and methods grew the environmental justice movement.

Traditional Environmental Movement

The initiatives and efforts of the traditional environmental movement did not include notions of justice and racism. The traditional environmental movement, and perhaps the one that became a dominant narrative for environmental education, comprises leaders like John Muir, Theodore Roosevelt, and other lovers of the wilderness. This wave, also deemed the second wave, began after World War II as petrochemical production quickly increased. In this era, environmentalists critiqued the widespread industrial pollution practices. Rachel Carson's *Silent Spring* was a prominent text in this discourse. While the traditional environmental movement benefited heavily from the Civil Rights Movement, they soon moved away from their orientation toward social justice. The second wave of environmentalism consisted heavily of lawyers who focused on framing and solving environmental problems with legal and scientific methods. Most of the environmental legislation we see today was written by these lawyers. The National Environmental Policy Act (NEPA), the Clean Air Act (CAA), the Clean Water Act (CWA), the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Federal Insecticide, Fungicide, Rodenticide Act (FIFRA), the Toxic Substances Control Act (TSCA), and the Superfund Amendment and Reauthorization Act (SARA) (Cole and Foster, 2000). While these acts did pave the way for incredible work toward remediating the environment, their emphasis on technical and scientific expertise excluded the voices of many of the people affected by these harms.

The emphasis of the traditional environmental movement during the late 1960s and 1970s was to litigate. In 1971, the Sierra Club surveyed its members, "Should the Club concern itself with the conservation problems of such special groups as the urban poor and ethnic minorities?" The responses were that membership "was against the Club so involving itself. [...] 50 percent of all members either strongly or somewhat opposed" the idea (Coombs in Cole and Foster, 2000, p. 30). Even though a major component in bringing environmental issues to light began with the environmental justice movement, the traditional environmental groups have separated themselves from these social justice efforts. While environmental justice is becoming more prominently intertwined with second-wave traditional environmental movements, many see the environmental justice component as a third-wave rather than an origination point.

Engineers play a critical role in environmental justice initiatives

Historically, engineers have played a major role in environmental racism. From the production of goods to the extraction of natural resources, engineering practice has contributed to many cases of environmental racism. Historically, environmental justice has not been included in traditional engineering practice or education (Cohen, 2020).

However, with the advent of environmental regulation after the 1960s, the emphasis on environmental engineering work became enrolled in the culture of environmental impact assessments. Environmental impact that attends to disparate impact of underserved communities historically has not been included in environmental impact work. In 1993, the Clinton Administration did incorporate risk assessment in US regulatory processes, which then was taken up by the EPA in an environmental justice initiative. In the EPA's definition of environmental justice, they stated "that no one group of people, including racial, ethnic or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences" (Clinton Administration, 1993). Further, Executive Order 12898 under the Clinton Administration was assigned as "Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations".

More recently, the Justice40 initiative and the increased acknowledgment of environmental racism in the academic and scientific literature have pushed legislators to integrate both environmental issues and racial issues. In 2022, the Biden Administration rolled out the Justice40 initiative, which has the goal:

> "40% of the overall benefits of certain Federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution." (Biden Administration, 2022).

While politically, environmental issues have been linked to issues of inequity, there is a need to bring understandings of environmental racism and environmental justice to engineering education.

Environmental Racism and Justice in Engineering Education

In engineering education, scholars have long emphasized the importance of bringing social justice literacies into the engineering curriculum. The topics of environmental racism and justice have been discussed in various ways by engineering educators largely through social justice frameworks. Through a social justice framing, scholars have brought topics on clean air, pollution, clean water, and energy access to engineering education (Bailey, 2020; Leydens & Lucena, 2015; Nieusma & Riley, 2010; O'Shea & Baillie, 2011; Riley, 2005; Tharakan, 2001).

Scholarship has emphasized environmental concerns and social justice broadly, but there are fewer studies focusing on environmental racism and environmental justice–namely where engineers attend to their position as carrying out and reinforcing practices that create or exacerbate environmental racism but holding engineering as neutral.

Recently, scholars published an editorial in the *Journal of Engineering Education* titled, "The climate is changing. Engineering Education needs to change as well" (Martin et al., 2022). The scholars bring attention to the changing climate to emphasize four points (1) connect climate and sustainability to engineering design, (2) value cross-disciplinary perspectives, (3) "understand the ethics and justice dimensions of engineering" and (4) "listen to and collaborate with diverse communities." (Martin et al., 2022, p. 740). In the third points, the authors discuss the importance of using frameworks of environmental justice and energy equity to develop technologies that do not disproportionately harm disadvantaged communities. In the fourth point, they focus on representation and collaboration with folks from diverse communities. They specifically note that climate change disproportionately affects "low-income and non-White communities" (Martin et al., 2022, p. 743). While the editorial offers several present-day examples to emphasize each of the four points, there is a lack of attention on the historical role engineers have carried on in creating and exacerbating environmental racism.

More generally, the emphasis of engineering education on environmental concerns is focused on mitigating environmental harm rather than attending to the intersections of income, class, race, and environmental harm or benefit. An understanding of environmental racism (past and present) and environmental justice (future) is needed for engineering students to move away from the illusion that engineering is neutral and context independent.

Methods

In this study, students engage with a variety of topics that are designed to help them think about historical inequities in society and how they continue to persist today. We focus on historical insights largely because engineering students are rarely exposed to integrations between societal issues and engineering work. Additionally, the emphasis on historical inequities is positioned to help them understand that using data as neutral only seeks to cement and scientize the inequities of the seeming past.

This study comes from the pilot year data of a three-year, NSF-funded study focused on improving sociotechnical literacy in a first-year engineering course. The "Introduction to Computing for Engineering" course has traditionally focused on teaching students a coding language as well as introducing them to the basics of data science. As part of this study, this course was re-designed to support sociotechnical thinking by adding three components: (1) weekly 20-minute in-class discussions reflecting on assigned readings, (2) a sociotechnical mid-semester project, and (3) including sociotechnical reflections in students' self-defined final

project. Students received additional support in sociotechnical topics from upper-class undergraduate “Equity Learning Assistants" (ELAs). Equity Learning Assistants attend separate weekly seminars that provide them with tools to support the first-year students in having sociotechnical conversations, then lead the weekly small and whole-group discussions during class.

This study focuses on the student reflections on the topic of environmental racism, from one of the weeks in this curricular revision. Other aspects of this project have been published in past ASEE conferences. One examines the perspectives of seven minoritized students who learn about engineering as a sociotechnical field (Ozkan & Andrews, 2022). Another is a work-in-progress study that examines student responses to the week on medical racism (Pangan & Andrews, 2022).

Study Participants

The majority of students in this study are first-years enrolled in the school of engineering. The study takes place at a medium-sized, private, predominantly white institution in the northeast region of the US. Responses were collected across two years of this sociotechnical engineering revision. In the first year, environmental racism was discussed in week seven of a 15-week semester, and in the second year, it was discussed in week four. This study is not intended to compare the two years but to understand the breadth of ideas and responses students have in response to reading and reflecting on the article. Notably, two class sections of the course were revised in year one of the projects (2021), and all five sections were revised in year two (2022). Each section is taught by a different engineering instructor. This study is not intended to compare students across different sections. Instead, through this qualitative thematic analysis, we attend to the different ways students take up and respond to social, political, and economic dimensions that have to do with environmental justice and environmental racism.

Curricular Revision on Environmental Racism

For the week on environmental racism, students were tasked with reading two articles. One from the Atlantic and one from Vox. The Atlantic article is titled “A New EPA Report Shows that Environmental Racism is Real” (Newkirk II, 2018), and the Vox article is titled “There’s a clear fix to helping Black communities fight pollution” (Ramirez, 2021).

Newkirk’s article in The Atlantic details a new report from the EPA that finds that “people of color are much more likely to live near polluters and breathe polluted air.” Newkirk discusses how qualitative data or storytelling has long been used in the Black community to raise concerns about the prevalence of hazards such as polluted air and water in their neighborhoods. The article discusses these concerns amid the recent findings of the EPA’s National Center for Environmental Assessment 2018 report that “people of color are much more likely to live near polluters and breathe polluted air” (Newkirk II, 2018).

The second article, by Rachel Ramirez in Vox, discusses the environmental justice movement and how they work to address these harms. The article describes the work of individuals working to fight development projects that perpetuate environmental harm in communities of color. Communities that already have issues with air pollution from past manufacturing facilities. Ramirez discusses the benefit of policies like the National Environmental Policy Act (NEPA) that local environmental justice organizations have in fighting these developments. NEPA is described as a:

> "bedrock law that requires federal agencies to consider the environmental impacts of proposed infrastructure such as the construction of major highways, prison complexes, airports, pipelines, landfills, and refineries. Passed by Congress in 1969, NEPA, followed by the Clean Air and Water Acts, was part of a broader plan to protect the environment from any point source of pollution or contamination." (Ramirez, 2021).

The article points out the limits of the law when it was created in that it omitted to include civil rights protections. Ramirez then traces a history of the environmental justice movement and how its roots lay with Black communities. Through several case studies, Ramirez traces the activism by various communities to then detail the development of environmental policies that have come after NEPA. Ultimately, the Vox article discusses the limits of NEPA as it does not address disparate harm to disadvantaged communities. Even if developers put together an environmental impact statement, the decision is up to states on whether or not they will allow a project to be developed. However, many states' heavy financial ties to oil and gas lobbyists make it such that these decisions are made with competing motivations.

These two articles were chosen to provide some insight into the issue of environmental racism and environmental justice. Students may not have wrestled with the notion of environmental racism before, with environmental movements and civil rights movements taught as distinct movements with a distinct set of solutions. However, through these readings and in-class discussions, we sought to bridge these histories together such that students would be better prepared to think through seemingly disparate issues together. To engage the students in the ideas of the articles, we provided students with three reading questions that they would respond to before coming to class. The questions are listed below:

1. What do you want to know more about regarding air pollution exposure across race and poverty level? What questions do you have?
2. How might past policies and events help you make more sense of the paper's findings?
3. As the study's authors write: "A focus on poverty to the exclusion of race may be insufficient to meet the needs of all burdened populations." The researchers found that even after accounting for poverty, they saw differential impacts based on race. Why do you think it is important to separate out race and poverty level and consider them as separate variables?

Research Aim

To understand the breadth of ideas and responses students have in response to reading and reflecting on the article.

Data Analysis

We take a case study approach to analyze the data collected during week seven from all five sections (Creswell & Poth, 2018). We used an iterative thematic analysis to search for patterns across the five sections (Braun & Clarke, 2006). First, the authors open-coded subsets from each of the five sections. Together we open-coded roughly 80 of the 167 total responses. We organized the open codes around larger themes and coded the full number of 167 responses. Because we are interested in how students demonstrate understandings of historical insight as it relates to present-day sociotechnical issues, our themes reflect these ideas. We took a "theoretical" thematic analysis approach, which is "driven by the researcher's theoretical or analytic interest in the area" (Braun & Clarke, 2006, p. 84). We consolidated codes again to the themes presented in this paper. To conclude the analysis, we conducted a final coding round with the themes in Table 1 until we reached theoretical saturation with the total responses. We discussed any codes that we had coded differently until we were able to reach a theoretical consensus.

The themes vary along a spectrum from superficial engagement to deep engagement with the ideas from the papers. Additionally, we noted where students focused on understanding the problem more or whether they focused on how to solve it. Lastly, we included instances when students noted a change in their ideas based on the readings. These themes are listed below in Table 1.

Findings

The students had varied ways in which they responded to the three questions. Some students responded to each question individually. Others tried to respond to all three in one paragraph. Due to the variation, we have organized the findings by theme and then with the question distinction in each theme.

As documented previously, students are coming to learn about environmental racism and justice from different positionalities and lived experiences. Some students expressed shock and disbelief at learning about environmental racism. Other students had an awareness and personal experience with these structural inequities. We organize the themes around this spectrum of engagement from 'disbelief at the harm' to connecting ideas to other learned experiences.' We also include themes that target students' stating a change in their ideas. Within this axis of superficial to deep understanding, there is a distinction between students focusing on

understanding the harm and the problem with those who are focusing on how to 'solve' the problems. We provide this table to organize the themes:

Table 1. Organizing Themes from Student Responses to Environmental Racism

<table>
<tr><td></td><td>Problem</td><td>Solution</td></tr>
<tr><td rowspan="4">Superficial
↕
Deep</td><td>1. Disbelief at the harm</td><td>2. Who's doing something about this?</td></tr>
<tr><td colspan="2">3. Has this been studied/regulated in different ways?</td></tr>
<tr><td colspan="2">4. The past was racist</td></tr>
<tr><td>5. Recognizing the importance of historical insights</td><td>6. We need to understand the past to solve the problem</td></tr>
<tr><td>Change</td><td colspan="2">7. Students expressing a change in understanding</td></tr>
<tr><td>Resistance</td><td colspan="2">8. Students expressing resistance to topics</td></tr>
</table>

1. Disbelief at the harm

Many students expressed confusion or disbelief at the reality of environmental racism in the US. The types of questions students offer in their responses exhibit a sense of searching for the 'real' reason environmental racism exists and persists. One student states:

> "I understand what the problem is, I just don't understand how or why it happened. Did these neighborhoods have the pollution before the minority populations moved on or after?"

This student continues on to question why these issues have not been addressed. Exclaiming that if "the pollution is so bad that the area is being called "cancer alley" why is no one doing anything about it? How can a company place a factory, give people cancer, then turn their backs on the issue?" The student raises legitimate questions about who is responsible and why action has not been taken. As the student reckons with the existence of a place called 'cancer alley,' they question the lack of action in rectifying this harm.

Another student expresses disbelief differently. They pose the question, "Why is pollution so high in these racially diverse and low-income communities?" The student goes on with a question. "And what is the true purpose of putting factories in these areas?" In this response, the student is searching for a clearer, more straightforward answer to the issue of environmental harms disproportionately affecting racially diverse and low-income communities than environmental racism, as is the article's topic.

Moving toward a deeper engagement with notions of environmental racism, another student points their questions at the "details about the decision-making process for [the] companies that introduce pollutants in the locations of their plants." The student continues, "Is their decision to build these plants in Black communities a conscious decision? Is it due to malicious intent, for self-gain (less likely to deal with pushback), or both?" While this student does not show similar disbelief as in the first two examples, this student is asking for more information that tries to make sense of the historical context with seeming disbelief that decisions were consciously targeting Black communities.

2. Who's doing something about this?

While the majority of students focused on understanding the problem better, many of them jumped quickly to how to solve it or questioned who is responsible for solving the issues outlined in the articles. One student pointed to political actors, asking, " What are lobbyists doing to help this issue? Has the Biden administration committed to anything to improve the conditions? What role does this issue play in the next presidential election?" While we do not have enough information to infer who the lobbyists are that the student brings up, it is clear that they locate a potential solution at the hands of these named political actors, perhaps not seeing an avenue for engineers.

A different student locates the responsibility at 'we.' In their response, they ask, "How do we fight this problem of racism when it concerns itself with air pollution? Should we start at the poverty level or go more into dismantling institutionalized racism?" This student asks how to go even start addressing the issue of racism and air pollution. They position poverty and institutionalized racism as separate in their second question, asking which one to prioritize.

3. Has this been studied/regulated in different ways?

A different set of students orient their responses around data collection and scientific studies on issues of environmental racism. One student notes that the advent of widespread data collection has helped awareness of issues. They state:

> "Past experiences allow us to have more information and data to defend our claim and what we want to change. For example, because there have been so many people who developed these health issues, we can now look into this problem on a worldly scale. The reason why is because we are now aware of the problem and can look for data in lower-class/ethnic neighborhoods."

This student's use of the term, we, in describing what is known because of data versus unknown signifies how this student puts trust in knowledge systems. Perhaps, this student has not been faced with issues of epistemic injustice, in that the lived experiences of many communities of color that are not 'studied' do not count until they become 'objectified' as data (D'Ignazio & Klein, 2020).

Another student states a similar idea about data as the previous student. This student relates the potential lack of scientific information during the time regulations were enacted in the past. They posit that:

> "Maybe there weren't regulations in place that prevented factories and plants from settling in a cheap neighborhood. If there were, then we can root the problem at racial injustices and work from there. If there weren't such regulations, maybe it is because we didn't have the access to science we have now."

This student hypothesizes that perhaps the science on environmental issues was limited and that may be why there were no regulations preventing environmental racism. They also state that if there were such policies, understanding this historical context would help to understand the root of racial injustices. While this student does inquire into the historical context, their emphasis on the lack of scientific information as a reason for injustice provides insight into their worldview.

A different student has a similar response. They also pose questions of when "these plants and other polluters began being implemented." They go on to state,

> "I assume the disproportionate pollution has been happening since the beginning, and I'm wondering what was going on in the country politically at the time. I'm curious about the knowledge we had at the time about the effects of living so close to factories and similar things. Was this something we could have foreseen or are we just noticing because of the effects showing now?"

The student questions the knowledge at the time of establishing the factories, questioning whether there was a lack of evidence that may help rationalize the effects of environmental racism. Seemingly, this student sees environmental racism as a present-day issue without the historical legacy it has followed. This is not isolated however, as a different student notes in their response that NEPA is focused on environmental impact and not racial discrimination because "this issue of environmental racism is so new, civil rights is not included in this act." From each of these responses, it becomes clear that there is a need to deepen their historical understanding of the environmental justice movement as well as address issues of what knowledge 'counts' and what knowledge can be discredited (Costanza-Chock, 2018).

Two different students provide examples of engaging with studies to draw their conclusions. One student puts it simply to the third question asking about the importance of separating the variables of race and income:

> "As the paper we read for the Tuesday lesson proved, racial disparity was still evident when the household incomes were neutralized, which shows money is not the reason behind the differences in conditions."

The student does not add context, but is direct about their response and cites an article from the course. They do not go into detail on how or why household incomes were neutralized or provide any other context on the study, but simply answer the question. A different student goes deeper in their response to cite a paper cited by the Vox article in their answer. This student provides

more context to add examples that extend racial issues from Black Americans to those who "might belong to Indian or Hispanic communities." In their response, they cite, "A professor of environmental policy at Texas Southern University [who] showed in his research that black people are treated unfairly. Additionally, "Black Americans in 19 states are 79 percent more likely to live with industrial pollution than white people" (Rachel Ramirez). That is why it is important to solve environmental injustice towards Black people[sic], since the problem is not simply poverty." This student relies on the information from the article and the cited study to answer the question of separating the variables, race, and income.

On the solution side, a student who discussed widespread data collection above discusses the need to engage with past policies. They state:

> "Past policies allow us to be knowledgeable about what is allowed and what is not. With having this information, we can pinpoint red flags and call out corporations and businesses that attempt to spread this problem even more. It also allows us to see what is left to be done. If we do not know what is being controlled/allowed we will not know in what direction to continue next."

This student points to past policies as a way to understand how industries can be called out today. They position this part of their response as a way to enforce existing regulations that are currently not being followed. Another student broached thinking about a solution by framing the issue in a binary ultimatum, where the options require "a lot of work" and might "not make a lot of sense."

> "I am also curious as to what we can do about this. It obviously doesn't make a lot of sense to relocate entire communities to places that are not surrounding big pollutants, but it also would be a lot of work to relocate the factories/plants/etc."

4. The Past Was Racist

Student responses fall under a fourth theme that locates issues of racism and environmental racism in the past. One student noted that at the time "these policies were created, people were very ignorant of the link between racism and the environment." Similar to the student who emphasized that 'we' now have an awareness of the problem, this student uses the term, 'people' in a monolithic way that tells us in so many words, who those people are–not the communities of color or Black activists who were at the front of the environmental justice movement. This student goes on to state, that:

> "The policies aren't adequate and are still in place today. This is an obvious piece of evidence that shows how little people cared about environmental racism, and the fact that these same policies are the main ones in place today shows it still hasn't been considered enough."

Again, noting that 'people' cared little about environmental racism and that there is much to be done. This student is engaging with historical issues as they relate to persisting inequities in the

present, but could deepen these reflections with an understanding of power/knowledge relations (Foucault, 1980) and epistemic injustice (Fricker, 2007).

A different student positions the historical context as "past policies from times of rampant racism." They go on to state that "there is still change that needs to happen, and now we have things to reflect on to make sure we don't go through anything similar." In this response, the student seems to be distinguishing different levels of racism over time, however they remain vague in how this might influence the "change that needs to happen."

5. Recognizing the importance of historical insights

While students varied in their engagement with historical insights, there were several who had deeper understandings of inequity in US histories. One student describes the way policies land differently for different communities, which goes beyond previous students' responses that used terms like 'we' and 'people' to homogenize varied experiences. The student states:

> "A deeper understanding of both the US history of environmental and civil rights policies with their intersections would help with the understanding of the different acts and legislature that both helps those communities at risk and jeopardizes them."

They go on to be more specific:

> "By understanding the motivation behind past policies and the population they were tailored for, we can then further make sense of why these policies have so much bias within them and how predominantly Black communities are constantly being left behind in the fight for environmental justice."

This student displays rich engagement with past policies that show an understanding that different groups, largely Black communities are not being protected by regulations that seemingly seek to improve environmental health. Another student explains that "historically the needs of underprivileged communities have been overlooked for centuries." They use these insights to pose questions of the data, "how accurate is the data that was presented? Are there more communities that have not been accounted for in this fight for environmental justice?"

A different student connects the insights from this week to another course they are taking. They state:

> "I'm currently taking a class on environmental policy, so I was happy to see mention of NEPA in the Vox article, which immediately came to mind when I began reading the Atlantic article. Of course, the Atlantic article was written during the Trump administration when environmental policy expectations were substantially lower. The "Executive Order On Advancing Racial Equity and Support for Underserved Communities Through the Federal Government" seems like a good jumping off point for the Biden administration, but we've yet to see significant progress in terms of affecting policy in a systematic way. I think Flint, Michigan is the most clear-cut example of

> environmental racism, though focusing on the one town might actually minimize the broad impacts of environmental racism."

This student goes so far as to bring in historical context of the articles being written, conveying that the Atlantic article was written in 2018, during the Trump administration. This student engages with the historical context from the article and of the article, then goes to connect the ideas to their insight from the environmental policy course, and brings it together to ask questions of the Biden administration. Similar to a previous student, this student does seem to locate responsibility with the political actors, which tells us as engineering educators that there is a need to deliberately pave pathways for engineering in these discussions.

In response to the third question on the importance of separating variables of race and income level, many students drew on historical insights, with some sharing their lived experiences and prior knowledge. One student states that in data analysis, "It's always important to separate race and poverty because racism is so deeply ingrained in the structure of the US." They go on to share their lived experience and then draw from the article to speculate on where polluting factories might be placed,

> "For example, in Minneapolis where I'm from, there are no roads to directly cross between historically black and historically wealthy white areas. These divisions were created by redlining and still remain today. Although I don't know for sure, I imagine that polluting factories might be more prevalent in the historically black neighborhood than the historically white one."

A different student notes that learning about "past policies and events make the paper's findings feel a lot more real." They go on to share,

> "Growing up right outside of a city and even in my own town, I have grown up hearing about the words redlining and about the effects of these processes. I however did not know the direct link between this and environmental racism. I knew it was there, but I didn't make that direct connection. The paper making this for you allows readers who know some of the topics, or none, to understand the connection and long history of this issue."

In this reflection, the student is able to make a connection between what they have learned about redlining and how these practices are linked to environmental racism.

In response to the third question asking about the separation of race and income in data analysis, some students drew from their knowledge of histories of oppression. In explaining connections between environmental inequity and race, a student points to "historical oppression in the United States." They go on to state, "While there are those that argue wealth is the determinant of location or residence and quality of the environment, the racial apartheid in the US and policies like redlining forced BIPOC communities into region perceived undesirable." This student concludes by saying that because of these histories of racial inequity, "regardless of changes in

modern wealth, majority BIPOC neighborhoods are still forced to deal with the worsening consequences of these past injustices." The student recognizes and uses their historical understanding to critique existing racial inequities.

A different student takes this analysis further by stating that there is a link between race and poverty "due to the denial of opportunities, education and good jobs because of how the systems in this country have been built around racist ideals." This student provides an example from the readings. They state, "Polluting industries are more likely to locate near predominantly black communities because it is 'easier' for them to do so." In response to the question of separating race and socio-economic status in data analysis, she states that the two factors are linked and that

> "It is important to separate out race and poverty because the experiences of a white person and non-white person who are both impoverished vary greatly because majority of the systems in play are legacies of white supremacy."

This student offers a nuanced understanding of the social and economic relationship between race and socioeconomic status, which they then are able to operationalize in their engagement in thinking of these two issues as separate variables.

6. We need to understand the past to solve the problem

Some students brought in their historical insights and curiosities as ways to cultivate solutions to the issues of environmental racism outlined in the articles. One student states that:

> "Past policies and events help us better understand how we got to this stage of environmental discrimination in the first place. Understanding our history and how laws have been interpreted in the past can also help us better understand our next steps toward fixing this issue."

While this can be construed as a blanket statement, the intention is that there is value in a historical understanding of problems that extends to their solutions. A different student brings in specificity in their response. They state,

> "To solve these problems would take far more explicit recognition and reparations towards colonial environmental violence directed at indigenous groups in N.A. and the ongoing environmental violence directed towards poor and BIPOC communities in the US."

This student brings in specificity and seemingly a prior understanding of reparations and colonialism in responding to these questions.

7. Students expressing a change in understanding

There were two students who stated that they learned something new or had a change in understanding regarding environmental racism. One student states that they were "initially not convinced there was a direct correlation [between environmental and racial inequity], but after reading the Warren County incident, [he] came to realize how factual this is." This student goes on to speculate, "I think the main reason why this has prevailed for a long time is the fact that

most minority races have very little representation in “high places” to help them when they protest these acts.” While the student’s speculation is limited and does not bring specificity into their understanding, they are starting to think through connections between the inequities in who makes decisions and who is impacted by them.

The second student states that these readings helped them realize connections between “environmental justice and the disparate impacts of climate change.” They go on to pose questions of engineers, asking “How have engineers acted in regards to these issues? Are engineers working to reduce environmental racism by specifically working with these communities?” While these are students who explicitly stated that they had a change in understanding, other students may have also experienced this but did not state this in their response.

8. Students expressing resistance to topics

Lastly, while the majority of the students took up the ideas and engaged with histories of environmental racism and justice to varying degrees of superficial to deeper engagements, there was one student who outright challenged the inclusion of this topic. In the response, the student states that the author’s claims are misguided and lack a corporate understanding. The student’s conception of racism is individualistic, stating they do not believe “CEOs around the country are pointing to black neighborhoods and saying, “build it there.” Racism for this student is defined as individual racist actions rather than the historical legacies of racist policy and action that persist today. Instead, the student attributes the cases of environmentally racist practices to those making the most economic sense–“business is doing what is cheap and easy.” The student goes on to state,

> “Capitalism is not so broken that corporations, with their notoriously tight profit margins and ruthless efficiency quotas, would spend the time and money to ask “whether people of color are around” before building their cancer factory. To determine otherwise is a gross misinterpretation of the supplied information, and a pathetic stretch of logic determined to call somebody else racist by any means. This line of thinking only works against the communities it claims to help, as activists and politicians take to their soapboxes to denounce the evils of “Environmental Racism”, then do nothing to protect these communities from corporations looking to save a buck by buying cheap land and forgoing safety standards. Also, this article has nothing to do with computers.”

This student expressed intense resistance to the articles detailing environmental racism in the US, ending their response with an emphasis that the article is irrelevant to computing. This type of response can be threatening to the instructor trying to integrate social justice topics in an engineering course and is a fear of many who have not faced this type of resistance in courses before. The student is disagreeing vehemently with the definition of racism as systemic and a product of legacies of racist policy that persist today, instead the student defines racism as individual racist actions on the part of the CEOs which he believes is not the case here. Part of

the curricular revision is to understand where students are at in their understanding and build from there, which is why there is an emphasis on asking questions in the response prompt.

Discussion and Conclusions

In this study, we examined the ways first-year engineering students took up notions of environmental racism and justice from learning about brief histories in their engineering computing course. Through this analysis, we found that students came to varied understandings in which they learned about the issues for the first time and/or connected the topics to their lived experiences and other courses. Their focus ranged from discussing the problems of environmental racism to suggesting and thinking through solutions in environmental justice. We examined their engagement with the variables, race and poverty level, in order to push them to see these variables as interrelated but requiring separation in data collection and analysis. In the prompt, there was an emphasis on students' asking their own questions which was helpful to examine the variation of student insight on the topics of environmental racism and justice.

Importantly, this module is small and only might seed an understanding that racism is structurally embedded in our systems of infrastructure and manufacturing. Based on the variability in how students took up these ideas–from one student's disbelief to another student's lived experience–there is a need to add variability to the subsequent pedagogy. A possible curricular extension to this small module would be to use the student responses to the module as a way to form groups. Students who had thought more deeply about issues of environmental justice and racism could work together and students who were newer to learning about these issues could be together. For the students sharing and connecting environmental racism to their lived experiences, there can be real harm in pairing them with the students who had yet to learn about environmental racism. For the students newer to topics in environmental racism, there is great benefit to helping them deepen their understanding of environmental racism and justice before embarking on other projects. By helping the more novice students productively engage with the past, we will help them ask more informed questions about the future (Wisnioski, 2015).

Next in the curricular sequence would be to bring connections for all of the students. Universities and colleges exist in a physical place that students may be unfamiliar with. There are many environmental justice organizations that do important work of bringing awareness to these issues, advocating for community members impacted by environmental racism, and in some cases collecting data to show disparate impact. In the Boston area, Greenroots Chelsea is one example of an organization that has advocated for and carried out more comprehensive air pollution data collection in Chelsea, MA to show the poor air quality in comparison to other parts of Boston (http://www.greenrootschelsea.org/). In Baltimore, MD, South Baltimore Community Land Trust (SBCLT) has created educational programs around the toxic incinerators in the area to advocate for their removal (https://www.sbclt.org/zero-waste/). Finding and highlighting local organizations can be impactful for students to see people working to make

tangible changes for environmental justice. However, in finding and potentially working with these organizations, faculty should take care to build relationships that are not solely in the interest of serving students' educational needs.

Lastly, there are students who may show resistance to learning about environmental racism or other 'isms' that can be jarring for the instructor. In the case of this course, the instructor immediately flagged the response and shared it with the larger project team with a question on how to address it. Because the student shared their response with the instructor through the form of an individual assignment, there is an opportunity to engage with their thoughts in a way that does not change the dynamic of the course. Engaging with the students' ideas is important, otherwise the student will garner the impression that the instructor is not as invested in the curricular choices. There is a need to take the student seriously in this context, thus, we recommend responding to the student in a way that treats their questions with diligence but stays isolated from class time and peer-to-peer interactions, where there is potential for epistemic harm. In addressing the student examined in this paper, the instructor could pose questions about how the student defines racism and think through impact versus intent. An option would be to pull directly from the article and discuss the cases shared to think through the points the student is making. For instance, the point on politicians doing nothing to protect the communities has some merit as many of the industries lobby hard against them to ensure that regulations are not enforced or if they are the fines are too low to warrant a change in action. The intention in opening up this dialogue is to engage the student and get them to pull on evidence and be clear about the words they are using. Of course, this requires time and effort on the part of the instructor (and the student if they choose to engage) that might be difficult for some in the middle of the semester. In addition to engaging the student individually, the more immediate concern would be to ensure that this student is not paired or grouped with minoritized students, particularly students of color, and that the instructor has a shared plan or classroom contract with students that aid in maintaining classroom decorum and respect.

Overall, the type of engagement with topics of environmental racism and justice will vary because students are not all the same. This variation in student ideas is important to attend to and can often be a great benefit for the learning environment, where students can bring their whole selves into the discipline. However, resistance to topics is a potential reality that should not be left out of the curriculum. When students challenge or resist ideas, they can be addressed in ways that do not harm other students in the course. Difficult conversations are important to bring into engineering, for if students do not learn to engage with difficult histories and concepts that engineering is a part of during their university time then where will they?

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