Evaluating Engineering Students' Moral Sensitivity in a Natural Disaster Context

Abstract

Engineered systems are designed to serve societal needs, from bridges providing mobility to communication systems enabling the transfer of information. It is essential that engineers recognize the social impact of their work to ensure they provide equitable benefits across communities when implementing such systems. In times of crisis, such as after natural disasters, these ethical considerations and awareness of community needs are especially important. Ethical development must begin when engineers are still students so that they can be trained to consider ethical issues before they begin working. Ethical development can be observed using James Rest's Four-Component Model of Morality: moral sensitivity, moral judgement, moral motivation, and moral behavior. Previous work has focused largely on the second stage, moral judgement, which describes the ability to determine which action is morally right when confronted with an ethical issue. Here, however, we focus on the first stage, moral sensitivity, emphasizing one's ability to recognize a moral issue. Studies show that while moral sensitivity does not always lead to moral behavior; moral sensitivity can help explain variances in moral behavior. Researchers argue that pinpointing students' gaps in moral sensitivity can help educators identify gaps in engineering ethics curriculum. Towards this goal, we interviewed undergraduate engineering students to evaluate their moral sensitivity, using a current event, the 2021 Hurricane Ida in Southern Louisiana, as background. This natural disaster provided a useful context to evaluate moral sensitivity due to the complex effects of such a crisis on engineered, natural, and social systems. The story is framed using Lind's Indicators of Ethical Sensitivity, providing the story characteristics, stakeholders, and consequences. We asked interviewees to provide the final indicator—ethical issues. Using a qualitative content analysis, we found that interviewees connected several ethical issues with the primary consequence of socioeconomic inequities. Identified ethical issues included topics of climate change, infrastructure, disaster planning, and corporate/government accountability. Implications of this study include recommendations for future moral sensitivity research and applications to improve classroom learning.

Introduction

Disasters are increasingly threatening our lives. In 2021 alone, the United States experienced 20 weather and climate disaster events with losses exceeding $1 billion and over 600 lives [1]. In addition to physical losses, disasters present ethical concerns: marginalized populations are more vulnerable and face more challenges in recovery, exacerbating existing socioeconomic inequities [2]. Engineered systems, such as water utilities and communication infrastructure typically sustain physical damage, leading to shutdowns and social impacts. During Hurricane Harvey, vulnerable residents in the Houston-Galveston area of Texas dealt with evacuation shelter deficits [3], and after Hurricane Katrina, many Southern Louisiana communities gentrified following the city's rebuilding efforts [4]. While the built environment is a major component of disaster damage and recovery, engineers often fail to consider the non-economic needs of communities in these situations [5]. Engineers are critical decision-makers in crises and have significant influence on post-disaster outcomes. However, it is unclear how widely-understood ethical considerations are

in these disaster situations, particularly by those engineers who have influence in infrastructure recovery.

From hurricane tracking to smartphone-assisted evacuation protocols, engineered systems play prominent roles in minimizing the impacts of disasters [6–8]. Engineers are expected to work according to codes of ethics, as put forth by their discipline's professional society. For instance, engineers are expected to "hold paramount the health, safety, and welfare of the public" [9–11]. These codes of ethics further include topics such as environmental protection and fair treatment of others. To continue integrating ethics into the culture of engineering, students must be trained to recognize these moral considerations. The Accreditation Board for Engineering and Technology (ABET) requires that undergraduate curriculum includes ethics training [12], and researchers insist that a paramount goal of engineering programs is to educate socially responsible engineers [13], [14]. However, it is unclear if engineering students are aware of their ethical responsibilities in real-world contexts or the impact they have on social issues.

We can observe students' moral sensitivity when faced with real world engineering dilemmas. Moral sensitivity is the first component of James Rest's Four-Component Model of Moral Behavior. This component describes one's awareness of moral issues and how their actions will affect others [15, 16]. Moral sensitivity includes the recognition that a situation includes a moral question [17]. While some researchers argue that moral sensitivity is a precursor to the second component in Rest's model, moral judgement, most researchers believe that there is insufficient evidence for this. Rather, the value in assessing moral sensitivity in individuals is that it allows for the identification in moral gaps, which can then be addressed.

Moral sensitivity is relevant in any discipline that can impact the well-being of people [18]. For instance, healthcare professionals must be aware that the quality of care, good or bad, can impact their patient's lives. Similarly, political leaders must be morally sensitive to situations that their constituents face. In engineering contexts, moral sensitivity is crucial because of the direct impact of engineering work on individuals. To be an effective engineer, one must understand the social, political, and economic contexts in which one's work exists, which requires an awareness of how technical systems impact others [19]. A morally sensitive engineer is more likely to take the well-being of others into consideration when designing, building a future that is more sustainable and more often prioritizes benefits to broad groups of people. Without moral sensitivity, engineers may, for instance, build systems that cause harm to the environment, neglect underprivileged populations when constructing infrastructure systems, and be more willing to do subpar work in exchange for personal benefit.

In this study, we seek to understand undergraduate engineering students' moral sensitivity. We aim to answer the question: do students exhibit moral sensitivity when faced with an ethical dilemma? To do this, we interviewed undergraduate engineering students, from first-year students to seniors, at a large public university in the Southern United States. In this paper, we focus on a sample of 11 interviews. Each interview included a story about Hurricane Ida's impact in Southern Louisiana in Fall 2021. This natural disaster provided a useful context for discussion due to the complex impacts on the local community. The story and questions were structured according to Lind et al.'s [15] Indicators of Ethical Sensitivity (i.e., story characteristics, stakeholders, consequences, and ethical issues). (Note that the terms "ethical sensitivity" and "moral sensitivity" can be used interchangeably; in this paper, we primarily use Rest's term "moral sensitivity" except

when specifically referring to Lind's framework.) The story includes story characteristics (e.g., a curfew was instituted in New Orleans), stakeholders (e.g., elderly residents), and consequences (e.g., drinking water was unsafe). The interview questions were designed to encourage participants to discuss the fourth indicator, ethical issues. Using a qualitative content analysis, we found that all participants focused on one major consequence, socioeconomic inequities, and connected this with several ethical issues, including government/corporate accountability, effects of climate change, infrastructure challenges, and inadequate disaster preparation.

By observing students' moral sensitivity, we can find gaps in students' awareness of ethical issues. We can further identify the issues of which students are especially aware, and find potential reasons for sensitivity to one issue over another. We are especially interested in understanding how students' experiences within engineering contexts (coursework, internships, student groups) inform their sensitivity. In identifying areas of awareness and areas with a lack of awareness, we can provide suggestions for improvement to engineering curriculum or other student experiences to develop moral sensitivity. Further, we identify that current events are especially effective in exposing students' moral sensitivity. In this paper, we explore the benefit of using a current event to discuss ethical issues, and recommend that educators use this approach in ethics lessons.

Literature Review

The foundations of moral development research begin in Piaget's stages of cognitive development, which Kohlberg expanded into his Theory of Moral Development [16, 20]. Kohlberg defined stages of moral judgement, which can only be achieved in a prescribed order: preconventional, conventional, and postconventional [21]. Rest, a student of Kohlberg, further expanded this theory into his Four-Component Model of Morality, representing the psychological processes that produce moral behavior, shown in Table 1 [16]. This four-component model includes moral sensitivity, moral judgement (from Kohlberg's theory), moral motivation, and moral behavior. These components should be viewed as processes and thus are not virtues that define someone as moral or immoral. They are also interactive, meaning they do not necessarily happen in a sequential order. To make a moral decision, a person must interpret the situation, understand the impacts of each potential course of action, select a course of action, and execute that choice [16, 17, 22].

Table 1: Rest's Four-Component Model of Moral Behavior [16]

Component	Definition
Moral Sensitivity	Awareness that a situation includes a moral issue and the potential impact on others
Moral Judgement	Ability to determine which action is most justified when confronted with a moral issue
Moral Motivation	Weighing options and making a decision about the course of action to take when confronted with a moral issue
Moral Behavior	Executing and implementing a plan of action in a moral situation

Ample research on moral judgement allows for an ease of evaluation regarding this component over the remaining three. The most common tool for measuring moral judgment is the Defining Issues Test (DIT), which provides scores based on the stages of Kohlberg's Theory of Moral Development [23–25]. The Defining Issues Test was revised over time in an effort to provide scores that better reflect ethical understanding, allowing for better evaluation using the DIT-2 (e.g. [26, 27]). Other ethics evaluations include the Perceptions and Attitudes toward Cheating among Engineering Students surveys (PACES), the Moral Judgement Test (MJT), and the Engineering and Science Issues Test (ESIT). Studies use the PACES-1 survey primarily to evaluate student perceptions and definitions of academic dishonesty [28, 29] while the PACES-2 survey is used to evaluate a theoretical model of ethical decision-making in cheating [27, 30]. The Moral Judgement Test (MJT) is based on Kohlberg's Moral Judgement Interview and is often utilized in non-engineering contexts, such as business [23, 31]. The Engineering and Science Issues Test (ESIT) was developed as an alternative to the DIT with an engineering focus. Studies using the ESIT can evaluate the ethical development of engineering students using scenarios that are more targeted toward their area of expertise (e.g. [32–34]). While there are many methods available for measuring moral development, no such standardized approaches exist specifically to evaluate moral sensitivity.

In engineering ethics education, case studies are often used to provide examples of challenging ethical situations [34–36]. These case studies are often historic engineering failures, such as the Chernobyl nuclear disaster [34] and the Challenger Space Shuttle Disaster [37]. In evaluating these case studies, students learn about critical moments in which an engineer was required to make a difficult decision, ultimately leading to disaster. Oftentimes, however, these case studies evaluate the technical failures more than moral decisions.

We depart from previous research in two key ways. First, in recognizing that significant research has been done on moral judgement, we instead focus on the first component of Rest's Four-Component Model of Moral Behavior: moral sensitivity. In evaluating moral sensitivity in an engineering context, we can better understand how engineers contextualize their work and recognize their social responsibilities as engineers. By focusing on undergraduate engineering students, we will be able to provide curriculum recommendations for moral sensitivity improvement. In fact, studies show that moral sensitivity does increase throughout students' training, in both discipline-specific and ethics-centered courses [17]. We further depart from existing ethical evaluation methods by contextualizing our work in a current event rather than a historic case study. In doing this, we encourage interview participants to apply their own lived experiences to their understanding of the story.

Methods

Interview Development

In Fall 2021, we interviewed undergraduate engineering students at a large public university in the Southern United States. As these interviews are part of a larger set of interviews aimed at fostering a culture of ethical engineering in student organizations, interviewees were recruited by contacting representatives through 11 engineering student organizations. Interviews were conducted via Zoom and recorded with permission. A graduate researcher, or an undergraduate researcher

supervised by a graduate researcher, conducted each interview. After transcribing the interviews by an outsourced firm, the manuscripts were reviewed by graduate and undergraduate researchers for content validation. The average duration of the section analyzed for this study was 10 minutes 36 seconds, while the average total duration was 32 minutes 10 seconds. The duration of the analyzed section varied between interviews, ranging from 5 minutes 15 seconds to 15 minutes 54 seconds.

Interview questions were developed by a team of graduate researchers and reviewed by a team of experts in a range of disciplines, including civil engineering, philosophy, political science, and anthropology. The interviews were developed using a funnel structure, where participants were first asked broad questions about their experiences as engineering students, then narrowed to more specific questions about ethical considerations in engineering, and finally ending with questions about socioeconomic inequities. This study focuses on a sub-section of the interview which included a story about the 2021 Hurricane Ida in Southern Louisiana, adapted from a New York Times article [38]. Participants were given the option of reading the story silently to themselves or listening to the interviewer read the story aloud.

The story was developed following Lind et al.'s [15] Indicators of Ethical Sensitivity, shown in Table 2. Story characteristics (e.g., a curfew was instituted in New Orleans), stakeholders (e.g., elderly residents), and consequences (e.g., drinking water was unsafe) are provided within the story. The interview questions were developed to assess participants' moral sensitivities to the ethical issues in the story. For instance, the story discusses the lack of communication from the energy company after the storm when many residents lost power. The story also discusses the issue that many residents were unable to evacuate after the storm. Participants were asked to identify and discuss these issues so that researchers could evaluate their moral sensitivity.

Table 2. Lind's Indicators of Ethical Sensitivity [15]

Indicator	**Definition**
Story Characteristics	Details that indicate what happened in the story, including facts and background information
Stakeholders	People, businesses, or groups who are involved or affected by an ethical decision
Consequences	Effects of an ethical decision and its impact on people
Ethical issues	Elements of a story which involve one's perception of "right" and "wrong"

Qualitative Content Analysis

Transcribed interviews underwent qualitative content analysis [39] using Dedoose [40]. This analysis process included two steps: (1) deductive coding using the four Indicators of Ethical Sensitivity, shown in Table 2, and (2) inductive coding of ethical issues, which allowed relevant sub-codes to emerge, shown in Table 3. Inductive coding allowed the responses to guide our work,

providing a deeper understanding of students' identification of ethical issues. Notably, a single response may be coded to multiple sub-codes simultaneously [39]. Each response was coded by two researchers and any discrepancies were discussed and reconciled based on the coding dictionary shown in Table 3 [41]. The project was reviewed by the University's Institutional Review Board.

Table 3: Coding Dictionary showing the ethical issues that participants identified in the Hurricane Ida story. These are the emergent codes developed from the inductive coding process.

Indicator	Definition	Example Interview Response
Effects of Climate Change	Changes to communities due to a changing climate and environment	"The hurricane probably wouldn't have been as bad as severe weather is getting worse and more frequent because of global climate change."
Infrastructure Challenges	Problems with infrastructure such as water utilities, electrical grids, transportation, etc.	"A neighborhood that doesn't have proper water infrastructure […] the damage will be worse compared to neighborhoods that do have that water infrastructure"
Lack of Corporate Accountability	Failure of a corporation to support its customers when it should be responsible	"It exposed the miscommunication or maybe the lack of accountability between the power company"
Lack of Government Accountability	Failure of a government to protect and support its constituents in uncertain times	"I think the lack of accountability from the government's mistakes. [The] residents mentioned they didn't have electricity and they had the boiling water notice and the government gave no timeline."
Inadequate Disaster Preparation	Lack of emergency planning within a community including resources and evacuations	"I think some important issues were the fact that they weren't prepared for when it did come, they didn't have supplies and they didn't have the resources to sustain them"

Limitations

As with any study, ours is not without limitations. Because this analysis is one part of a larger study exploring engineering ethics in student organizations, participants represent memberships in various student organizations. The 11 interviews chosen for this study each represent one of the 11 student groups. This preliminary study allowed the researchers to explore areas of potential future research, including improvement to curricular development. Future work will include a greater number of interviews to further evaluate the engineering student population.

Results & Discussion

The story provided to participants in this interview discussed the aftermath of Hurricane Ida in Southern Louisiana. This story was structured to include Lind et al.'s Indicators of Ethical Sensitivity [15]. The *story characteristics* included details such as curfews, gas shortages, and

population statistics. The *stakeholders* included elderly, minority, and low-income residents, as well as the governor and energy company. The consequences included power outages, inability to evacuate, and socioeconomic inequities. Thus, our analysis focused on the last indicator, *ethical issues,* and socioeconomic inequities as a key consequence because every participant discussed this consequence in their interview. Participants discussed various aspects of socioeconomic inequities including low median income, high percentage of elderly population, and unequal treatment of communities of color.

Further, we evaluate five *ethical issues,* shown in Figure 1, in connection to socioeconomic inequities, which we use to examine students' moral sensitivity. Moral sensitivity to ethical issues includes both an identification and an explanation of its importance [17, 42]. When evaluating interview responses, we recognize a student's moral sensitivity when they include both of these factors. These ethical issues provide a useful tool for examining moral sensitivity because it demonstrates the areas of awareness for engineering students, and allows us to find the gaps in awareness. It is especially interesting to evaluate ethical issues in connection to socioeconomic inequities because participants recognized that socioeconomic inequities were exacerbated by the ethical issues. The ethical issues that emerged from the inductive coding process include effects of climate change, infrastructure challenges, inadequate disaster preparation, lack of government accountability, and corporate accountability, as shown in Figure 1.

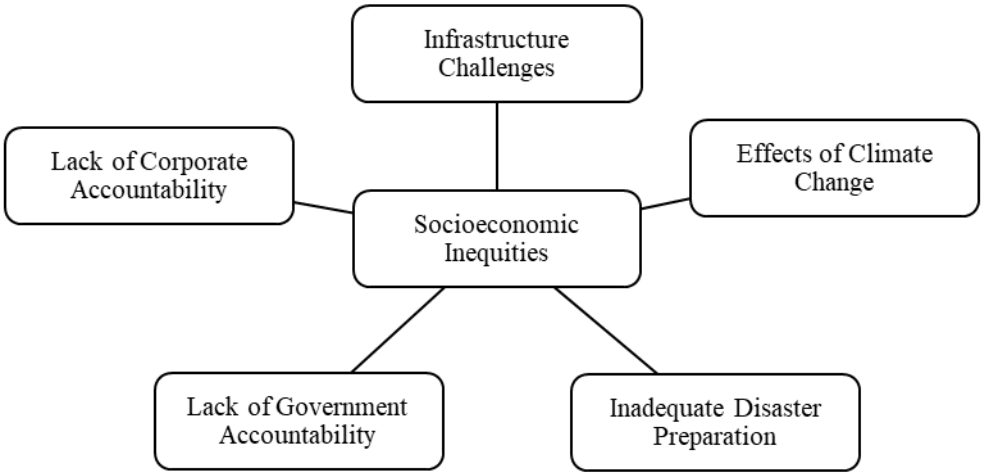

Figure 1: All participants recognized socioeconomic inequities as the key consequence in the story. They further connected this consequence to the five ethical issues shown here.

Seven participants identified *Lack of Government Accountability* as an important issue in the story. Interviewees discussed government leadership's failure to communicate, fairly represent constituents, plan for long-term challenges, prepare for natural disasters, and adequately fund infrastructure. All of these participants also included discussions of socioeconomic inequities, recognizing that government decisions can have significant impacts, particularly on those who rely on government programs for financial support. Participants argued that the government's inadequate response to the hurricane had more severe consequences for less privileged groups, particularly because those people had more difficulties and fewer funds to relocate. One participant drew connections between funding, campaigning, and infrastructure planning, stating that "…the

Texas power grid hasn't been upgraded in so long because no one wants to spend that much money because it doesn't help get re-elected. I think that same problem hit Louisiana…I bet they could have done more with the right people in leadership." This is significant because it shows that students recognize that the government has a responsibility to represent the needs of its constituents.

Notably, the core curriculum at the students' university requires that every undergraduate student enroll in two government courses, which may account for the number of participants who identified *Lack of Government Accountability* as an ethical issue in this story. Through coursework, students are taught that the United States Government has a duty to protect its citizens, and the awareness of that cultural principle is clearly displayed in these results. Because these courses increase awareness of government responsibility, students may be more sensitive to situations when the government does not fulfill these expectations. The engineering students who were interviewed in this study demonstrated a concern for citizens who were impacted by government decisions or lack of government action. Thus, further investigation of the impact of non-engineering coursework, specifically government-focused courses, on students' moral sensitivity, may provide evidence for this impact.

In addition to government-focused coursework, engineering students at the university included in this study are required to enroll in an engineering communications course. It appears that many of the students who were interviewed have taken important lessons from this course, as well, emphasizing the value of communication between government, corporations, and the public. One participant identified this ethical issue, stating that "the lack of communication and not keeping the general public in the know of when they should expect the power, the different sort of storm advisories, the boil water notice" was a major problem. Communication was discussed in the context of two ethical issues: *Lack of Government Accountability* and *Lack of Corporate Accountability*; students explicitly listed communication as a duty of government and corporations in more than half of the interviews conducted. In engineering work, both during a disaster and not, communication is vital to public safety and to the completion of a successful project. In disaster contexts, especially, clear communication is necessary before the disaster event and during recovery so that residents can access temporary shelters, are aware of transportation route closures, and are prepared for the loss of power or potable water [43]. The students interviewed here appeared to recognize that communication is essential to protecting the safety and welfare of the public. While there may be many factors influencing students' recognition of the value of communication, the engineering communications courses are likely a significant factor. Further investigation into these courses may provide specific reasons and evidence for this influence.

In discussing government and corporate accountability in this story, many participants discussed their own experiences with similar natural disaster situations. One such event was the Texas Power Grid failure after Winter Storm Uri, a record-breaking snow and ice storm that forced Texas into rolling power outages and boil water notices for nearly two weeks [44]. The university these students attended was closed for nine days, and much of student housing was without power, without running water, or flooded, meaning it affected most or all of our interview participants. The Winter Storm Uri example demonstrated that engineering students learn from their own experiences outside of classrooms. By connecting the story in the interview to their own stories, participants demonstrated that an effective method of pursuing moral sensitivity is this connection

to personal experiences. Educators can use this finding to improve ethics education in engineering courses by selecting case studies that are relatable and current, allowing students to better understand the impacts of disaster situations on others and increase moral sensitivity.

Several respondents discussed the ethical issue, *Effects of Climate Change,* in connection with *Socioeconomic Inequities.* Many participants demonstrated a moral sensitivity to the disparate impacts of climate change on vulnerable populations. For instance, one student said that climate change is "not going to affect everyone the same […] In fact, a hurricane is probably a great example of how climate change will impact, not the people creating the pollution, but the people [in areas] that don't have the kind of infrastructure to survive." The awareness of this discrepancy is valuable for engineering students, as their future work may be able to either help or continue to harm those affected communities. Recognizing that many engineering Codes of Ethics include language around environmental protections [9–11], it appears that students are learning to connect environmental challenges, human impact, and engineering solutions. Engineering courses that include lessons on the Codes of Ethics may be contributing to the development of students' moral sensitivities.

Several participants discussed the ethical issue of *Infrastructure Challenges* associated with *Socioeconomic Inequities.* In these discussions, students demonstrated a moral sensitivity to the responsibility that engineers have to communities to build reliable infrastructure, including transportation networks, water utilities, and communication systems. In the story students read, students argued that there appeared to be a disproportionate impact on low-income and minority communities when infrastructure failed after the storm. For instance, one participant, in discussing water quality and infrastructure resiliency issues stated that "normally it's low income residents, people who don't have the means to rebuild their house after it's flooded for the sixteenth time", who are most affected. Infrastructure failures in these communities can lead to public health and safety implications, including poor access to clean drinking water [45] or unreliable public transportation access [46]. The historic disinvestment in public infrastructure in primarily minority and low-income communities has exacerbated these challenges. In disaster situations, like Hurricane Ida in Southern Louisiana, the lack of investment is magnified, as neglected infrastructure fails more quickly. By demonstrating a moral sensitivity to these challenges, participants are showing that they recognize the impact of engineering work on vulnerable communities.

Participants connected the ethical issue *Inadequate Disaster Preparation* with the consequence of *Socioeconomic Inequities*. In discussing this ethical issue, participants recognized that the community should have better emergency planning in place for natural disasters, especially in a location where hurricanes and flooding are becoming more frequent. This moral sensitivity identifies that community members and leaders should consider vulnerable populations, recognizing that minority and low-income groups sustain greater harm when emergency planning is inadequate. This systemic problem can be mitigated with clearer and more robust evacuation plans and more frequent communication. Engineers specifically can plan for disasters by maintaining and bolstering infrastructure to better withstand extreme weather events. One participant who discussed the need for disaster preparation at length pointed to the Code of Ethics and an engineering course in which this was taught. It was clear that this course had a significant

impact on their understanding of engineer's responsibilities, and was able to connect this recent hurricane with their lessons.

Implications

This study demonstrates that engineering students do exhibit moral sensitivity when faced with an ethical dilemma. Students are aware of some of the social impacts of engineering work, a minimum, during crises. This moral sensitivity is important in natural disaster contexts, especially, because of the disparate impacts of extreme events on vulnerable populations. The functioning and resiliency of infrastructure systems, including transportation networks, water utilities, and communication systems, are crucial in disaster contexts. By recognizing the potential impacts, engineers can ensure safer recovery for communities. It is likely that students recognize inequities in disaster contexts because they are sudden, short, and extreme. However, socioeconomic inequities in the built environment and social system are in fact prolonged and systemic. In this study alone, it is unclear if students recognize these socioeconomic inequities in non-disaster situations, but research indicates that many do not [47]. Perhaps future research could compare two different cases, using a disaster story such as the one used here, as well as a story demonstrating more systemic inequities.

This study departed from traditional disaster case studies in that it used a current event story rather than a historic engineering failure. This proved to be effective in encouraging students to consider the stakeholders involved in the project and the issues at play. Many students discussed their own experiences with similar disasters and were able to connect those experiences with the engineering ethics discussion. Future research might explore this further and recommend changes to curriculum, focusing on relatable current events rather than historic case studies. Future work might additionally expand upon the moral sensitivity findings to observe if its development in engineers directly leads to more ethical engineering projects.

Conclusion

To evaluate moral sensitivity in engineering students, this study evaluated students' reactions to a natural disaster story, focusing on students' identification of ethical issues as key indicators of moral sensitivity. The research team conducted interviews with undergraduate engineering students and used qualitive content analysis to analyze the results of 11 interviews. The qualitative content analysis employed Lind et al.'s [15] Indicators of Ethical Sensitivity as a useful analysis framework. Results show that all participants identified Socioeconomic Inequities as a major consequence of Hurricane Ida and subsequent events. In connection with this consequence, students identified five ethical issues including *Effects of Climate Change, Infrastructure Challenges, Inadequate Disaster Preparation, Lack of Corporate Accountability,* and *Lack of Government Accountability.* Results show that students develop moral sensitivity various ways, including coursework and lived experiences. It is noteworthy that several participants discussed ethical issues in context of non-engineering coursework, rather than engineering coursework. While interdisciplinary lessons are invaluable, this demonstrates a gap in engineering education that should be studied further. This study further shows the value in incorporating current events into engineering education, rather than focusing on historic case studies of engineering failures. When presented with a story that they are already familiar with, students can better contextualize

the application of their engineering studies to the social impacts. Future work will expand upon this study to include a larger sample size and consider institutional factors.

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