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Talk (Engineering) Ethics to Me: Student Group Discussions about Ethical Scenarios

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**Abstract: Talk (Engineering) Ethics to Me:
Student Group Discussions about Ethical Scenarios**

The past twenty years have seen the blossoming of ethics education in undergraduate engineering programs, largely as a response to the large-scale and high-impact engineering disasters that have occured since the turn of the century. The functional form of this education differs significantly among institutions, and in recent years active learning that demonstrates a strong impact on students' retention and synthesis of new material has taken hold as the preferred educational methodology. Among active learning strategies, gamified or playful learning has grown in popularity, with substantial evidence indicating that games can increase student participation and social interaction with their classmates and with the subject matter.

A key goal of engineering ethics education is for students to learn how to identify, frame, and resolve ethical dilemmas. These dilemmas occur naturally in social situations, in which an individual must reconcile opposing priorities and viewpoints. Thus, it seems natural that as a part of their ethics education, students should discuss contextualized engineering ethical situations with their peers. How these discussions play out, and the manner in which students (particularly first-year engineering students) address and resolve ethical dilemmas in a group setting is the main topic of this research paper.

In this study, first-year engineering students from three universities across the northeastern USA participated in group discussions involving engineering ethical scenarios derived from the Engineering Ethics Reasoning Instrument (EERI) and Toxic Workplaces: A Cooperative Ethics Card Game (a game developed by the researchers). Questions were posed to the student groups, which center upon concepts such as integrity, conflicting obligations, and the contextual nature of ethical decision making. An a priori coding schema based on these concepts was applied to analyze the student responses, based upon earlier iterations of this procedure performed in previous years of the study.

The primary results from this research aim to provide some insight about first-year engineering students' mindsets when identifying, framing, and resolving ethical dilemmas. This information can inform ethics education design and development strategies. Furthermore, the experimental procedure is designed to provide a curated series of ethical engineering scenarios with accompanying discussion questions that could be adopted in any first-year classroom for instructional and assessment purposes.

Talk (Engineering) Ethics to Me: Student Group Discussions about Ethical Scenarios

Introduction

The past twenty years have seen the blossoming of ethics education in undergraduate engineering programs, largely as a response to the large-scale and high-impact engineering disasters that have occured since the turn of the century. The functional form of this education differs significantly among institutions [1-3], and in recent years active learning that demonstrates a strong impact on students' retention and synthesis of new material has taken hold as the preferred educational methodology [4-5]. Among active learning strategies, gamified or playful learning has grown in popularity, with substantial evidence indicating that games can increase student participation and social interaction with their classmates and with the subject matter [6-8]. Engineering education (ethics or otherwise) has likewise seen a growth in the direction of gamified or playful learning in part due to the ability of games to provide a safe environment in which to explore, make mistakes, and *discuss* the ramifications of various decisions in authentic contexts [9].

These observations motivated the present study, which is a part of a larger, multi-institutional NSF-Funded research collaboration [10] aimed at developing a suite of engineering ethics games that focus on the social and behavioral aspects of ethical decision making in an engineering context, targeted towards first-year engineering students. As a part of this study, it is important to establish the qualitative "baseline" which describes how first-year engineering students approach and resolve engineering ethical problems. In particular, this paper aims to answer the research question:

How do engineering students reason through engineering-ethical scenarios prior to college-level ethics education?

A key goal of engineering ethics education is for students to learn how to identify, frame, and resolve ethical dilemmas. These dilemmas occur naturally in social situations, requiring the reconciliation of opposing priorities and viewpoints. Thus, it seems natural that engineering students should discuss contextualized ethical situations with their peers, rather than in isolation. Likewise, approaching ethical scenarios in a group discussion context is arguably a better analog for what may occur in a *gamified learning environment* than having students tackle ethical scenarios on their own. How such discussions play out, and the manner in which first-year engineering students address and resolve ethical dilemmas in a group setting is the main topic of this research paper.

The primary results from this research aim to provide some insight about first-year engineering students' mindsets when identifying, framing, and resolving ethical dilemmas. This information can inform ethics education design and development strategies. Furthermore, the experimental procedure is also designed to provide instructors with a curated series of ethical engineering scenarios and accompanying discussion questions that could be adopted in any first-year classroom for instructional and asessment purposes.

Methods

Recruitment of Subjects

Recruitment of participants took place at three northeastern universities (University of Pittsburgh, Rowan University, and University of Connecticut), via an email announcement and in-class recruiting. Then, students who were interested were asked to fill out an availability form in order to be added to the participation pool. Students were next asked to state their age and sign the survey consent form to be considered for the study. Students were chosen from the pool on a first-come-first-served basis, and those who were under 18 or who did not consent were removed from the pool. Consent forms were obtained for the discussions via an electronic IRB-approved form.

Discussion Sessions

Each discussion session (N = 7 participants across three (3) discussions, Fall 2021) took place virtually on WebEx, with one PI acting as a moderator (webcam + mic on), while the other PI (webcam+mic off) took field notes. The participants were required to keep their webcams and microphones on for the duration of the discussions. The discussion subject matter for this study is derived from ethical scenarios that are available in the literature, including two scenarios taken from the Engineering Ethical Reasoning Instrument (EERI) titled “Nurse Scheduling Software” and “Water Quality Testing” [11] and two from Toxic Workplaces: A Cooperative Ethics Card Game, titled “O-no rings” and “Lose the Ooze”, developed by the research team [12]. Each of the scenarios placed the students in the role of an professional engineer (Toxic Workplaces) or engineering student (EERI) faced with an ethical dilemma, to which they must decide a course of action. To help stimulate conversation, the research team employed a series of questions to bookend each scenario. The first two questions (1-2) were mandatory, as was the final question (8). If the conversation stalled or went off topic, the moderator could ask a series of supplementary prompt questions (3-7) to get the discussion back on track. The complete list of questions is provided below.

Initial Mandatory Questions

1.) Recap the scenario with your group. What is the issue that must be addressed?
2.) Explain your individual course of action to your group

Prompt questions

3.) Who do you identify the most with in this scenario? The least?

    a.) Whose opinions/interests (of the people in the situation) matter the most? The least?

4.) Who would be affected by your decision? Of those, whose interests are the most important? The least?
5.) How might those affected by your decision react to your decision? Does it matter?
6.) How ethical does your choice of action feel to you?
7.) What aspect of the scenario do you feel affected your decision the most?

Final Mandatory Question

8.) After discussing the situation with your peers, do you still feel the same way as you did when you first made your decision? Why or why not?

After the discussions were finished, each student also filled out a brief survey to capture basic demographic information to help characterize the sample.

Data & Analysis

Raw data for this study consists of the transcribed audio recordings of the discussion sessions as well as the demographic survey responses. The audio recordings were transcribed using Rev.com. The demographic survey was administered online using Qualtrics. Subjects were verbally informed that the sessions would be recorded and asked for their consent before recording. The transcribed discussions were analyzed by a group of four senior undergraduate engineering students as a part of a *Research and Independent Study* course led by the first author in the Spring of 2022. The coding process used as a basis the codebook that developed during a preliminary Spring 2021 study [13]. For the Spring 2022 analysis phase, room was allowed for the addition, subtraction, merger, or division of codes based on the new sample. Discussions were coded on the basis of individual utterances, grouping sentences together when they fell into the same theme. Inter-rater agreement was established by collaborative discussion, with the PIs acting as moderators.

Schematization of Coded Responses

The coded responses can be schematized into four broad categories that describe the emergent themes appearing in the discussions. These schema and codes are provided below, along with several exemplar quotes:

Schema 0: Moral Agency

(0.1) **Powerlessness/Inevitability -** Reports stating that their choices will not affect the outcome, or that one outcome is inevitable, regardless of their intervention.

(0.2) **Passing the Buck -** Passing responsibility off to someone else.

Schema 0 includes two codes that both speak to the sense of moral agency felt by the student respondents. In several instances, students responded that they felt their choices would not affect the overall outcome of the situation, or that they felt powerless to have any effect on the scenario despite their choice:

"Scheduling has always been an issue and even looking into certain job fields, not everything can get done on time or not everything can be done correctly on time. And that's just something that you're going to have to sacrifice to stay within the law and the boundaries that you've given."

This perceived lack of agency is an interesting feature of the discussions, and its psychological underpinnings are an area of active research in behavioral ethics [14-16]. Likewise, there were several cases in which students responded that the ultimate responsibility for the scenario rested with an individual senior to themselves, thereby absolving themselves of responsibility for their choice:

"I would probably just explain to the secretary first. 'Hey, I know you mentioned that the IT guy would be here by this time, but I do have to get going for my final exam. Unless he can get here, the final piece of code will not be able to be installed and the system may expire.'"

This code appeared most frequently in the *Nurse Schedule Software* (EERI) scenario, in which a student is reliant on a senior technician to finalize a project. The technician is late to work, and their tardiness tends to be the focal point of the discussion for this scenario.

Schema 1: Spheres of Personal Interest and Impact

(1.1) **Personal Welfare** - concern about the consequences of their decision upon themselves.

(1.2) **Economic Concern** - concern for their own personal financial position as well as that of their company, neighboring town, or community.

(1.3) **Environmental Concerns** - concern for the environment or effects/impacts on wildlife

(1.4) **Risk -** discussion of the risk (likelihood & consequences of an event) involving any or all parties, often including the possibility of a known or unknown negative outcome.

Four of the codes observed have directly to do with the spheres of personal interest of the students as they are responding to the scenario. The frequent presence of these codes suggests that participating students can readily place themselves in the position of the decision-maker in the scenario - i.e. the scenarios are *relatable* to first-year engineering students, despite their occasional lack of similar prior experiences. Likewise, these students place a particular emphasis on the direct effects of their decisions on their own welfare, which should be considered a normal response [17]. It is hypothesized that the highly situational nature of these scenarios, and the fact that all of the respondents are *engineering students* themselves, may enhance the relatability and interest with the scenarios. Respondents also readily expand their sphere of interest to include their communities and others directly affected by their decision making, including environmental concerns where relevant, indicating an ability to assess the broader ramifications of their actions. One facet of this schema which may be of special interest to engineering educators is the articulation of positions incorporating the element of *risk,* such as:

"I mean, I would still report it just because I think it's important. Having any risk at all, in my opinion, is still a risk even when it's small."

Risk assessment and analysis are integral to many engineering curricula, though usually at a stage later than the first-year. Exceptions to this rule typically occur in first-year engineering ethics modules or first-year design courses, which may include some elements of risk assessment from a safety or investment perspective. Importantly, none of the students had such instruction at the time of the data collection.

Schema 2: Ethical and Moral Principles

(2.1) **Concern for Others** - Concern for the health, safety, security of people possibly affected by the scenario.

(2.2) **Duty and Responsibility** - a sense of moral obligation that also includes "doing what you're told" or a normative sense of what should/should not be done.

(2.3) **Good of the Many vs. the Few -** A majority rule, emphasizing benefitting more people over less - looking at the bigger picture beyond just individual experiences.

Several of the codes have direct analogues to well-established normative moral and ethical models as elucidated by Gilligan [18], Bentham [19] and Kant [20], despite the respondents lack of formal ethics training. This should come as little surprise, as all of us are immersed from a young age in the moral and ethical frameworks of our respective cultures. However, it is interesting to note the relative frequency and interplay of these codes - i.e. how students reconcile the often conflicting conclusions that could be drawn by taking different ethical approaches to resolving the dilemma. This aspect of the coding is outlined in the scenario-specific analysis, below.

From an engineering ethics perspective, it is also important to acknowledge what does *not* show up in the discussions: namely, any direct reference to engineering codes of ethics. Discussion of engineering codes, such as those espoused by the NSPE including “holding paramount the safety, health and welfare of the public,” “performing services only in … areas of competence,” [21] and several themes about professional honesty [21] are all touched upon obliquely and naturally by the students, but without knowing that these are fundamental canons of engineering practice. For example, several references are made to professional duty, based entirely on the student’s own perceptions of what that duty is:

“So in any scenario you should always, I feel like as an engineer or just as a person in general, you should always value someone's life over money, and the most ethical thing to do would be to protect people.”

The extent to which students acquire knowledge of professional ethics codes and assimilate them to their own emerging identity as professional engineers is an open question, and one which is of particular interest for future studies.

Schema 3: Rationalization and Problem-Solving

(3.1) **Communication** - choosing to use communication as a solution to the dilemma. Communication can include reporting to superiors as well as to the public.

(3.2) **Looking for More Information** - seeking clarification to help come to a decision or choice of action.

(3.3) **Extrapolating Information -** inferring or assuming additional information to justify a course of action.

(3.4) **Prior Knowledge** - recognizing analogous cases and using them to inform or resolve the dilemma.

The last schema is composed of observed behaviors that relied heavily on rationalization and critical thinking skills, which are traditionally heavily associated with engineering problem solving. Frequently, students assumed that a potential ethical issue could be easily resolved or “worked around” by communicating the issue to other parties involved. In other cases, students asked the discussion moderator for clarification or more information about a scenario. In these cases, the moderator would only provide information if it was explicitly stated in the scenario and was a point of confusion for the students (such as not knowing the definition of a word or the context of a technical procedure). Lack of what the students consider sufficient information often leads to extrapolation as a way of justifying their choice:

"It wasn't very clear about prior communication, but I would assume that if you had a final exam in this big software thing, they would've communicated that."

It is important to note that the scope of the information provided by each scenario varies across the instruments. In particular, there is substantially more situational and personal information provided in the Toxic Workplaces scenarios than in the EERI scenarios. This issue is compounded by the fact that the Toxic Workplaces scenarios are based on real life situations. It is notable that in all of the discussions, both the O-no rings scenario (based on the Challenger explosion) and the Lose the Ooze scenario (based on the Boston Molasses Flood) were recognized as being similar to real-life events. Students reported several sources of their familiarity with this information, with both Youtube.com and prior exposure in engineering classes being common. This information is of particular interest to engineering instructors, who may be able to build on student familiarity with other scenarios to increase their logical connections between ethics, decision making, and real-world consequences.

Scenario-Specific Analysis

Scenario One: Nurse Scheduling Software

In scenario one, students grappled with the decision of whether to update student-developed scheduling software used by nurses in a hospital in the absence of oversight by an IT supervisor who is late to work. The situation is complicated by the fact that the student has an exam scheduled later in the day, that they may miss if the supervisor doesn't come soon. Out of all four scenarios, respondents empathized the most with the events and ethical decisions they were faced with in this scenario, as evidenced by the high percentage of observed Schema 1 (Spheres of Personal Interest) codes. Similarly, as the individual in this scenario is a student themselves, there was a frequent assumption that the student programmer is not wholly qualified or responsible for resolving the software issue. Extrapolating information (27%) was noted to be the most commonly observed code in the responses to this scenario. The use of this strategy in particular can be attributed to the lack of information in the scenario itself with regard to the rules and regulations within the hospital environment. Some examples of the respondent-extrapolated information ranged from "mayhem within the hospital" to HIPAA violations. It is hypothesized that the lack of situational detail in this scenario prompted a significant amount of the extrapolation and rationalization used to justify the respondents' decided course of action. Additional prevalent codes included passing the buck (16.2%) and personal welfare (13.5%) – likely due to the respondents' perceived lack of authoritative agency in the situation (see discussion above) and the seemingly more personally-important exam scheduled for later in the day.

Scenario 2: Water Quality Testing

In this scenario a team of students performed water quality testing in a creek downstream from a large manufacturing plant as part of a design project. When some of the samples came back positive for high levels of harmful contaminants, it was recognized that some of the local children who frequently play in and near the stream may have been at risk of exposure. This scenario likewise includes a substantial amount of information about the potential environmental impacts related to the presence of pollutants in the water, and it is hypothesized that these more concrete consequences (relative to Scenario 1) encouraged more duty & responsibility responses (21.7%) than Scenario 1 (5.4%). Additionally, concern for others (26.1%) superseded economic concern (0%) in this Scenario, as exemplified by the following response:

"I feel like the long term effects of children playing in [sic] pollutants, versus shutting down a manufacturing plant, are so much greater. You don't know the long term effects of being around that."

It is evident based on the responses that students readily put themselves in the position of the people living by the polluted creek and focused on the human impact of their decision. Further comparing Scenarios 1 and 2, the responses to Scenario 2 do not exhibit the code "passing the buck" at all. This indicates that the respondents failed to recognize that there is an additional responsible figure in the scenario - their instructor - who theoretically bears more responsibility for disseminating the results of the study.

Scenario 3: O-no Rings

In this scenario, the respondents were put in the position of a professional working for a company developing O-rings. The O-rings are stated to be sensitive to temperature, and if the product is subjected to low temperatures, there is a substantial risk of failure (>10%). The respondent is then faced with the information that the product is being utilized in a NASA mission during cold weather. The respondent is also provided with several pieces of additional information about potential political, media and financial fall-out if the mission is terminated. The scenario closes by asking the students what is to be done when their product is utilized in an irresponsible and potentially dangerous way.

Given the similarity of this scenario to the famous NASA Challenger explosion, many students referred to this and other famous space-shuttle catastrophes in crafting their responses. While Scenario 3 is fabricated, its real-world connections and implications had a collective and attitudinal impact on the respondents; this is hypothesized to be related to the fact that the scope and profile of the scenario itself is richer in detail than those of the EERI-based Scenarios 1 and 2. Given the magnitude of the possible effects of their decision, participants often focused on relatively passive forms of resolution, such as communicating (29.4%) or passing the buck

(23.5%) to higher-ups within their company. Despite this, there is little sentiment of powerlessness or inevitability (5.9%), perhaps because the scenario places the respondent in a position with some direct agency, requiring the students to make a decision, even if it is relatively passive. It then follows that looking for more information (11.8%) and a risk (11.8%) assessment were applied frequently as respondents appeared to be more cautious in their resolutions, likely due to their knowledge of analogous real-life scenarios. With regard to "risk", the scenario itself mentions different forms of risk explicitly, forcing the respondents to consider risk directly. Notably, "looking for more information" was actually observed *more than* "extrapolating information" (4.8%) in this scenario, which is counterintuitive considering the relative richness of situational information provided to the respondents.

Scenario 4: Lose the Ooze

This scenario revolves around a lead safety inspector who inspects a molasses company's holding tanks and finds a potential hazard involving cheap rivets, the failure of which could result in a severe spill. The inspector could either include this information in their report or leave this fact out in order to allow the molasses company to pass inspection. By leaving the concern about the rivets out of the report, the inspector would not only receive their own bonus, but would receive a portion of the molasses company's bonus for passing (a bribe). The inspector was also assured by the company that the bolts were designed to last for at least another five years, and that the company would make the necessary changes to the rivets well before then.

Similarly to Scenario 3, the discussion surrounding this scenario was not a "clean slate" type of discussion (like Scenario 1 and 2) for the respondents, since they were all already familiar with the Boston molasses flood which this scenario is modeled after. Knowing the outcome and criticisms of the company at fault in the actual event prior to participating in the study could have resulted in more biased responses from the participants than if the scenario was previously unknown to them. Likewise, it is plausible that the direct knowledge of the Boston incident influenced respondents who might have otherwise chosen to accept the company's bribe. Admittedly, it is also possible that the respondents would not admit they would accept the bribe when forced to discuss this situation among their peers, as opposed to facing this situation individually. Overall, the most dominant codes observed in this scenario were extrapolating information (35.3%), duty and responsibility (23.5%), and risk (17.6%). These observations are consistent with the fact that the participants were familiar with the real life scenario and were able to extrapolate information from this prior knowledge in order to assess the potential risks and make ethically responsible decisions themselves.

Demographic Snapshot

While it is not being used for drawing conclusions about the qualitative data collected above, the collected demographic information nonetheless is helpful in understanding the particular subject population and contextualizing the responses. The demographic survey found the six (6) of the seven (7) total subjects to be 18 y.o. and the eldest being 19 y.o., with biological sex of four (4) female and three (3) male. The breakdown by Race/Ethnicity was one (1) African American/Black, one (1) Asian/Pacific Islander, one (1) Hispanic, four (4) Caucasian (other than Hispanic). All subjects had English as their primary language, and one (1) out of the seven (7) total had an vocational/technical background prior to their first-year in an engineering program (all others were first-time-full-time engineering students). The breakdown of participants by university was University of Pittsburgh - two (2), Rowan University - one (1), University of Connecticut - four (4).

Summary and Future Work

In this study, student groups discussed a suite of four engineering ethics scenarios which all required them to make a decision about a course of action, individually and collectively. The responses to these scenarios grouped into four schemas, which touched upon the students' sense of moral agency, their spheres of personal interest, basic ethical and moral principles, and critical-thinking/problem solving strategies. Topics particular to the engineering profession, such as risk assessment and professional duty appear occasionally, despite the students' lack of formal training in engineering ethics and risk management. This speaks to the students' sense of identity as engineers-in-training, and is an important point to keep in mind during formative instruction. Future iterations of this study may investigate topics such as group dynamics during ethics discussions, and the role that personal experience, prior knowledge and nascent engineering identity may play in engineering ethics decision-making in group scenarios.

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