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Reengineering ethics education for deeper student engagement through the creation of roleplaying and decision-making games [WIP Paper, Student Experiences]

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Shreya Kumar and Megan Levis

ABSTRACT

Engineering ethics is an area of increasing importance today, and this sentiment is shared by educators and budding engineers alike. However, engineering curricula do not often integrate ethics related to engineering specific topics. And even when these topics are incorporated, students are often left wanting to know how they would apply historical or philosophical knowledge of ethics in their future engineering industry lives that they are preparing for. We share our multi-year, multidisciplinary endeavours in understanding the problem area through qualitative interviews and surveys. We also describe our attempts to integrate engineering ethics in different courses for different audiences, in different capacities. Our goal of this work is to help students better engage with engineering ethics and feel a better sense of ownership and a clearer understanding of their future responsibilities towards ethics in daily decision making. We leverage discussion, teamwork, guided questions, role playing and decision making games to help students engage with seemingly esoteric topics. We help students build and employ their own frameworks, vocabulary and sense of rubric for tackling simple decisions, while also considering their potential ethical connotations and implications. Throughout this entire process, we were careful to employ student participation and feedback at all stages, allowing for a strongly student-driven approach. Students explored ethical education of engineers and developed digital learning tools, as those served as excellent opportunities for students to engage with this subject matter in with depth. We share our lessons and challenges in attempting to find adequate means to assess this work in meeting long-term and far-reaching educational goals.

INTRODUCTION

Culture and technology interact now more than ever in the history of engineering. While that has fostered innovation from and into all sectors of life and society, thoughtful consideration of the ethics of engineering endeavors and education has not kept up. While there are major ethical implications of engineering that go beyond simple academic thought experiments, engineers typically graduate without a strong sense of ownership of their future ethical responsibilities[1]. Evidence suggests that typically, engineers' sense of civic responsibility declines over the course of their engineering education, as studied by Cech[2]. Pierrakos et. al[3], in their work on reimagining ethics in engineering curricula, acknowledge this culture of disengagement and piecemeal treatment of ethical roles[4][5] as a driving reason requiring re-engagement. These studies

inspired our work.

In this paper, we describe our pan-engineering efforts working with faculty, alumni and undergraduate students from many engineering disciplines to help determine if our understanding of the need to integrate better ethics engagement is echoed by other faculty and students. This investigation was conducted over several years, in different capacities. The early investigation focused on computing ethics content across the computing curriculum. Over the years, different groups of computing students in software development courses were recruited to help design and develop a student-driven ethics-based gamified web tool, based on simple decision making and role playing. Here we leverage the work of Hingle[6],[7] where they describe how they have used role playing in the ethics engineering classroom to effectively have students grasp the details of major engineering disasters. We also build upon the work of Johri and Hingle[8] who describe their success in using role play discussions in identifying different levels of ethical concerns.

A few scenario creation workshops were organized where different batches of undergraduate computing students worked in teams to sketch and create ethics based decision making scenarios using paper or blackboard. This scenario creation activity model was later refined and employed in different Ethics in Engineering courses as a means to increase engagement through gameplay and role playing.

In 2022, this work was expanded by joining forces with engineering faculty from the Virtues and Vocations initiative and the Ethics at Work project which included other computing faculty, faculty from Aerospace and Mechanical Engineering, and faculty from Philosophy, where the goal was to capture an engineering wide faculty and undergraduate student sentiment about ethics content in engineering. A multidisciplinary team of undergraduates, led by advising faculty (authors), was formed to design and conduct the interviews and surveys to assess the needs of and sentiments about ethics across the entire engineering curriculum.

On examining the current state of ethics integration in engineering in the US, as reported by Hess and Fore[9] who share their extensive literature review of ethics interventions in engineering, we find that across the US, and even within our college of engineering, there is some disparity in access to and requirement of ethics related to engineering.

One major finding from our analyses was that surprisingly, undergraduate engineering students expressed an interest in wanting to understand the ethics of different aspects of engineering as discussed in the Student Engagement Section of this paper. This may be notably different from the typical undergraduate as described by Balakrishnan and Tarlochan[10] who share about engineering students' attitudes towards ethics in the engineering curriculum. They found that interest in socio-ethical issues is typically low. However, at the University of Notre Dame, all undergraduate students take multiple philosophy and theology courses[11]. These required courses engender social consciousness in our students. We find that engineering students frequently ask the question, "How can I engineer for good in the world?" this aligned with the university motto of being a force for good in the world. Balakrishnan, Tochinai and Kanemitsu[12] compare the integration of ethics in the engineering curriculum in Japan and Malaysia and found that greater ethics integration in engineering curriculum correlated more positively to students attitude towards ethics and their educational objectives for ethics being attained. We observed similar advantages to having greater ethics exposure in our curriculum.

Students found that the access to engineering-related ethics education within the engineering curriculum was limited, and the existing philosophy and ethics courses were interesting and exposed them to thought-provoking material. Still, students struggled to relate their philosophy and theology education to their careers in the engineering industry. In our work, we have found that dialogue drives expanding of the mind. A lot of the discussion, even on engineering topics was an important exposure to root causes of disasters and growing concerns around a lack of diversity and understanding standards of professionalism, but students hoped that they would have a rubric or framework through which they can assess and prepare for the ethical challenges in their roles as decision makers.

We also were pleasantly surprised to learn that faculty largely recognize the need to discuss ethics related to their courses and have the inclination to engage their students with ethics content in non-ethics courses, but they shared some challenges. We found that for most engineering faculty, there is a lack of space in their courses and time to develop or curate such material, another is a perceived lack of expertise in discussing ethical and philosophical frameworks. Many engineering faculty said that it is outside of their research areas and they would struggle to know where to start, even though they acknowledge that this integration would be beneficial to students and would help them understand the whole picture of where their knowledge situates them. Another concern expressed by faculty was that they believed that a lot of notions of ethics are being formed by students in courses outside engineering or even outside the university, which may not connect with the ways we find ethics issues in engineering may need to be discussed.

Through several years of interviews and analysis, we have identified the major goals for our work:

(1) Find ways to engage students with engineering ethics-based content such that they engage more deeply than their previous engagement, they perceive ownership of ethics, and they find relatable ways that they would apply their knowledge to their experience in industry. This is mainly measured through self reporting and interviews.

(2) Find ways that educators can integrate such content easily into their courses with low barriers to integration. Ideally, instructors can outsource ethics content relevant to the courses via tools or other interventions.

In this paper, we describe three major aspects to our approach toward serving these goals:

(1) Understanding faculty and student sentiment and need about ethics in engineering education.

(2) Developing and deploying classroom interventions and activities used in ethics and non-ethics engineering courses. We share details and examples of some of our activities, including examples of student made scenarios. We share our challenges and reflections about the process.

(3) Developing and curating different resources for ethics educators through the Virtues and Vocations and Ethics at Work initiatives and through a student developed ethics tool.

INTERDISCIPLINARY AND PAN-INTITAIVE COLLABORATION

Virtues and Vocations initiative

These endeavors came into contact with the Virtues and Vocations initiative at the University of Notre Dame's Center for Social Concerns. The Center for Social Concerns is an interdisciplinary institute dedicated to justice education and research for the common good with communities near and far[13]. Virtues and Vocations is a national forum for scholars and practitioners across disciplines to consider how best to cultivate character in pre-professional and professional education[14]. In the fall of 2022, engineering faculty from across the US gathered for a workshop on virtues and vocations here at Notre Dame. This endeavor lead to a diversity of conversations about character and pre-professional formation both inside and outside the classroom. The outcomes of this workshop included a deep dive with faculty and administration at approximately 20 schools of varying sizes and ages of programs. The major theme that came out of this was the discussion of curricular and co-curricular approaches. There was extensive discussion about the assessment of these approaches with solutions involving students writing their own learning goals, there being personal development goals alongside learning goals, and even the mentioning of emails from students a few years out of the program. These discussions revealed that character formation can take many forms and that assessment of these interventions remains challenging at the classroom and university-wide level. This workshop has led to a working group at Notre Dame to rethink the approach to character formation for engineering students across the College of Engineering. This is an ongoing project that has informed our approach at various stages and remains an active area of conversation and pedagogical development.

Ethics at Work

Dr. Levis is part of the Ethics at Work Project[15]. It is a pedagogical collaboration with a computer science professor (Dr. Walter Scierer) and a philosophy professor (Dr. Paul Blaschko) at Notre Dame. This work has led to her connection with the Virues and Vocations Initiative. The Ethics at Work Project has created a number of resources that may be useful to other professors teaching a class that involves ethics at all different levels.

For engineering professors looking to think more deeply about ethics at varying levels of time commitment:

- Ethics at work database[15] has pedagogical and educational materials ranging from op-eds to reading quizzes of material, focusing on material and means to assess reading. There are over 500 entries and counting.
- Ethics at work has also created a YouTube channel[16] with a series of videos for courses on work and the good life, ethical and professional issues in computer science, technology self and society, and the archaeology of hacking. These short 2-10 minute explainer videos can be used as preparatory material for courses.

IDENTIFYING THE PROBLEM SPACE THROUGH INTERVIEWS AND SURVEYS

In this section, we describe some details of our multi-step approach towards determining sentiment and challenges to integrating ethics-based content in an engineering curriculum as perceived by both faculty and undergraduates. We were intentional in engaging undergraduate students to conduct this work, as the design and articulation of the problem area itself is an engagement opportunity for students.

The needs and challenges identified through this work helped shape our classroom interventions and instructional resources.

Computing faculty interviews

In the spring of 2018, we conducted interviews of almost all the faculty in the Computer Science and Engineering Department.

At the University of Notre Dame, we have an incredible opportunity to engage students in deep, meaningful conversations about technology ethics. All our undergraduates have to take required courses in philosophy and theology, giving them a strong grounding in considering ethics as a question. We have multiple centers of research and outreach on campus that work in the field of tech ethics. However, in the engineering curricula, we do not connect the background and knowledge of ethics with the engineering topics that our undergraduates study.

Students in the Computer Science and Engineering department learn ethics in a required senior level course called Ethics and Professional Issues in Computing. Students across all the other engineering disciplines do not have any required engineering ethics course. For some study abroad student offerings, there is an Ethics in Engineering course that counts as a technical elective for engineers, but there are no offerings of this course for non study abroad students. Those attending that particular study abroad opportunity have to take that ethics course. More recently, Dr. Levis created a technical elective course on tech ethics for the college of engineering as a whole. Her class fulfills a university-wide writing intensive requirement so students from across the college electing to take her course. Her course is called Technology, Self and Society.

In separate student interviews and student feedback, computing undergraduate students have shared that they appreciate the senior level ethics course, but find that they do not really know how to think about ethics in their work. They do not know know how to assess the potential ethical implications and impact of their decisions. They assume those things are probably related, but do not feel like they know how to make those connections on their own.

One of the major outcomes of the faculty interviews was that we were able to clearly articulate our goal of student ownership of ethics and how even though ethics is important at all levels and in all computing topics, there are some barriers for faculty to teach about it and integrate it in their courses. Some of those barriers include lack of space in already packed courses where introducing one topic would mean another topic has to be left out.

Another barrier was that many faculty stated that they do not feel like they have the expertise or the philosophical background to discuss the ethics of some of the relevant topics, and that it

would perhaps be better served by those who have a background in philosophy and other ethics based standards and frameworks. We found that these findings were validated again a few years later when faculty across the College of Engineering were interviewed. This is discussed more in the Student Engagement Section.

When asked if there existed an activity where a topic relevant to their course was analyzed for ethical merit, would faculty prefer to send students to tackle that outside of the classroom, many expressed an interest in that. This could help take the onus of new ethics based content creation off the faculty member's shoulders and still be used related to their course without giving up precious lecture time.

We also received feedback from students that in previous iterations of the required, senior-level ethics and professional issues in computing course, there were some lectures where the free and open discussion became difficult and contentious. Some students shared that it was upsetting to hear hurtful personal views of other students about diversity and the place of women in computing. Considering that the students at our university come from different parts of the political and class spectra, it can be intimidating to voice personal thoughts and opinions. We identified the need for having a safe space build on trust where different issues can be discussed without feeling personally attacked or having to be uncomfortably vulnerable.

To serve these identified goals, we decided to engage students to develop an ethics scenarios website, where faculty could send students to engage in different topics of engineering ethics. To make this engagement less burdensome and more fulfilling, especially in helping students visualize how they would tackle engineering ethics related issues, we chose to have the ethics scenarios be something that leverages role play and gamification. The scenarios are like mini decision making games, that students play through, temporarily inhabiting the engineering roles they will soon be working in. The scenarios themselves are created by their own undergraduate peers, so they reflect on the situations that students are concerned about tackling. The scenarios are also meant to help reinforce that their engineering specific ethical dilemmas may not have very easy or obvious choices and that their knowledge of ethical frameworks or biases may help them make informed determinations. By having a tool built for the students and designed by the students, we hoped to have even greater engagement in the topics of engineering ethics.

We also determined that students needed a mechanism to be able to share different thoughts and ideas in their analysis of varied ethics topics, where the thoughts are not shared as personal opinion and where students do not feel like they have to share more about their political, gender or class leanings than they want to willingly volunteer. A mechanism that allows for students to use abstractions in order to analyze and think about issues in ways other than their personal biases and experiences would permit.

Student-driven exploration - faculty interviews and undergraduate surveys

As part of the aforementioned virtues and vocations collaboration the authors along with a professor in mechanical engineering, led a student project last semester to assess the sentiment towards ethics education among undergraduate engineering students and faculty at the University of Notre Dame. This student group was in our socially engaged computing projects class. They

conducted interviews with key faculty members that were engaged in a variety of ethics and engineering endeavors.

Outcomes from the faculty interviews:

A group of undergraduate students interviewed a number of faculty in engineering and philosophy.

From the faculty interviews, some key concerns identified, which echoed what we had learned from computing faculty interviews as well :

- Time/limited resources for courses
- Lack of ethics expertise for engineering professors and associated fears of teaching outside their expertise
- How will this fit into an already packed curriculum?

Key desires coming out of these interviews

- The University of Notre Dame has a distinct mission to form students who are aware of their ethical responsibility to the world
- There are many ethical issues worthy of study like bias built into many fields
- Several tools exist online to help students begin thinking about ethics and engineering like MIT's Moral Machine tool[17].

The students then used a mind mapping miro board tool to cluster faculty responses. An example of the Notre Dame university specific response cluster is shown in figure 1. Each color represents a different professor, and the black square is the title of the cluster. The similarities and differences in responses are highlighted when clustered together graphically.

Outcomes from the student surveys:

In addition to the faculty surveys the student group also designed and implemented a survey for undergraduate engineering students. They explored their fellow classmates' experiences with and interest in ethics education within their respective programs. As part of this endeavor, the students were encouraged to have ownership of every part of the process, the faculty mentors served as clients to mimic a professional engineering design process. Here the act of creation was more important than the outcome.

In the survey, students were asked a series of questions from across the College of Engineering. They were asked about their experience taking courses at University of Notre Dame. Only 14 students responded, but this gave some interesting insights. The demographics of respondents included: 64% seniors, 21% juniors, 7% sophomores, and 7% freshmen. With regards to the distribution of majors: 57% Computer Science, 21% Electrical, and 21% Civil and Environmental. University of Notre Dame Our university requires all undergraduate students to take two philosophy and two theology courses, students were asked if they had taken either or both courses respondents: 86% had taken both, 7% had only taken philosophy, and 7% had only taken theology, 0% had taken neither. This indicates that the majority of respondents had a working knowledge of both philosophy and theology basics from those courses. Another key

Figure 1: Student-developed Miro board clustering of faculty responses showing a Notre Dame specific cluster, collected during faculty interviews with student team. Each color represents a different faculty member. Note, the authors rearranged the for readability as a figure, previously the notes were more spread out.

takeaway of the survey was that 64 % of respondents wanted to see ethics incorporated into engineering classes, while only 21% wanted stand-alone ethics classes, 7% reported ”don’t wish to study ethics in my engineering courses,” and 7% reported” Both, it’s important to have ethics classes, but by having units within technicals shows that ethics are always important”. These results indicate that University of University of Notre Dame Students are interested in seeing ethics in their engineering courses as a whole.

Though the student surveys were limited this led the students to brainstorm a number of unique ideas for classroom and campus interventions. Students proposed:

- Podcast with ethical issues of the week
- Ethical hot takes, where dualing positions are presented as blog posts
- Videos from ethics professors
- Post-mortem ethical ”failure analysis” similar to other types of failure analsyses

STUDENT ENGAGEMENT THROUGH CLASSROOM INTERVENTIONS

In this section, we describe some of the classroom interventions that were designed and refined over multiple years to be used in an Ethics in Engineering course. This work is built upon the previous work of Kumar and Kremer-Herman[18] where certain interventions were piloted in a senior level Ethical and Professional Issues in Computing course, introducing philosophical frameworks as a lens to analyze ethical issues.

Our classroom activities concerning ethics spanned a number of different courses taken in different contexts. Some ethics courses were required for computer science students, some were elective for engineering students, but were offered in a study abroad program where all students attending had to take that particular course. One iteration of the ethics in engineering course was online and one was in person. Some of the course activities detailed here are for elective ethics courses. And some ethics activities were incorporated in non ethics courses, such as software development courses or computing projects courses. Whether a course was required or not, and whether the course was specifically an ethics course or not, affected how we designed and administered our ethics engagement.

Required Ethics courses

We outline some of the activities we used in the Ethics in Engineering course, one iteration of the course online and one in person. The in person version of the course in Summer 2022 was part of a popular summer engineering abroad program, where all 60+ students participating in the program had to take the course, making it required for those students. The online version of the course was held in Summer 2021, a COVID summer, where only those students who chose to attend an online course enrolled. The summer courses met for 2 hour long sessions every day for 6 weeks, making it an intense experience.

Based on prior work in other versions of the ethics courses aimed at computing science and engineering students and another version of the course aimed at students from any discipline, we found that one of the major challenges in discussing ethics, especially with engineers is the general subjectivity of the topic. We found that engineers prefer to have a framework and vocabulary to assess things, as opposed to completely open ended conversation. We have found that it helps engineers avoid the hesitation one might experience in stating their personal opinions, when they can discuss and analyze a matter in the context of a mutually agreed upon and scientifically validated vocabulary.

Bias and Philosophical frameworks

In the beginning of the course, we delved into the topics of bias - starting with reading articles about different types of cognitive bias[19][20] , moving on to systemic bias and then discussing bias in technology. We started by agreeing that there are several types of biases applicable in any topic that we study and why we might tend to interpret a topic a particular way because of our own personal biases or because of bias in the data collection and interpretation or the storytelling of an incident post hoc.

Early on, we established that all of the work in the course would be through validated lenses (ethical frameworks and identified cognitive biases). This notion was comforting to many engineering students, most of whom were rising sophomores or rising juniors, who may have been apprehensive about the potentially subjective and soft skills nature of the course. This was an important step towards getting buy-in and active and enthusiastic participation.

Swan, Kulich and Wallace describe their examination of ethics gaps in the engineering curriculum[21] and its relation with student behavior in ethics code violations. They report that most engineering ethics curricula favor utilitarianism and deontology more than other

Table 1: List of ethical frameworks that we chose to use in the classroom for their different emphasis areas

Ethical Framework	Lens or area of emphasis
Virtue Ethics	emphasizes virtue or character instead of duties or rules.
Utilitarianism	morally correct action produces the most good. Focus on actions
Ethics of Care	understand and analyze how gender should affect or is ignored within ethical frameworks
Aristotle's Ethics	focus on human well being
Deontological Ethics	focus on action according to duty, not focusing on consequence.
Confucian Ethics	combining personal, social and political duties as a collective lens
Epicurean Ethics	focus on pursuing individual happiness and pleasure as a moral framework
Stoic Ethics	combining physics, logic and ethics
Egoist Ethics	emphasis on pursuing personal welfare
Business Ethics	emphasis on ethics related to transaction of goods and services
Environmental Ethics	emphasis on relationship and responsibility to the environment

philosophical frameworks. In our course, we chose to discuss and analyze ten philosophical frameworks that could help us examine an issue from vastly different perspectives. The frameworks we chose to include in our vocabulary are shared in Table 1 as described in the Stanford Encyclopedia of Philosophy[22].

An important goal of establishing the initial vocabulary was to force students to think about things from different lenses, especially ones that are counter to their natural inclinations.

This establishing frames and lenses was done intentionally to address past issues with the discussion space, where upsetting scenes from discussion of polarizing topics and hurtful comments made the classroom space unfruitful. We wanted to be able to build a space where there is trust and comfort to foster conversation and discussion, but also the ability to state anything through an abstraction or lens, without feeling attacked or the need to defend one's personal opinions. This corresponds with the notion of psychological safety as described by Newman et al.[23], and Beigpourian et. al.[24] in discussing its merits for exploring new ideas and for better teamwork outcomes.

Collaborative deep dive with ethical questions

Students were placed in groups and given a topic to research. All groups were given a different aspect of the central issue as a topic. Each group was also given a subsection of shared slides based on that topic. The entire class would live edit their slides, for everyone else to see. The slides would be one of their major course deliverables.

Along with a topic, students were also given specific prompts to examine their assigned topics from different lenses described below,

1. facts and description with sources - establishing what are facts related to their timeline of incidents and a description of the topic in general,
2. ethical questions - then students were asked to develop some ethical questions based on their topic.
3. bias examination - students were asked to examine each topic and the actions taken in the

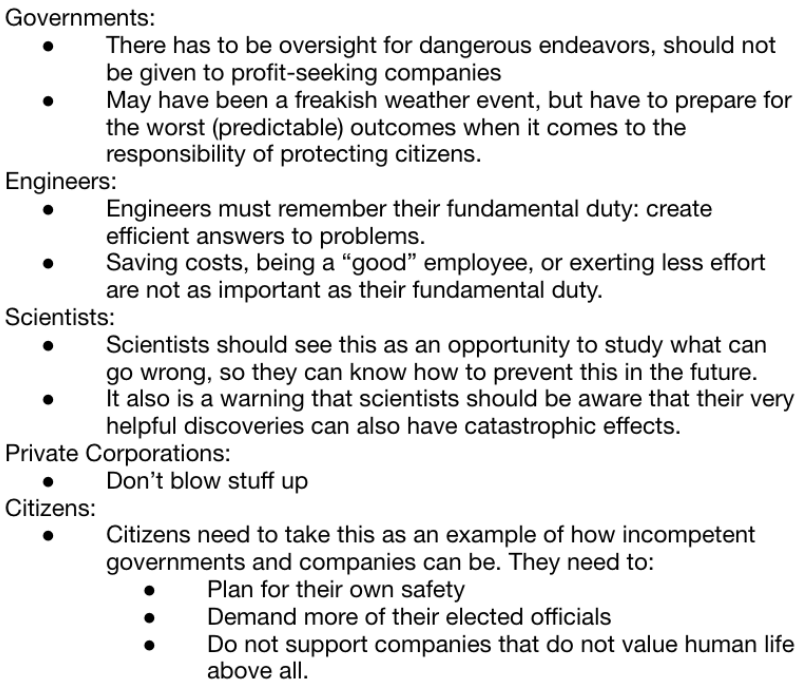

Figure 2: Snippets of student submitted role-based lessons from the Fukushima nuclear disaster.

incident using the lens of different types of cognitive bias, which may have affected their decision making

4. framework assessments - students were asked to determine how different philosophical frameworks would assess their topic, again aimed at forcing them to think through lenses and aspects that would

5. learning - students were asked to consider different roles e.g. the government, the engineers involved in the incident, any private corporations that were involved, citizens affected by the incident and citizens in general and then describe what each role could and should have learned from this incident. See figure 2 for an example of what one student group presented as role based lessons that should have been learned from the Fukushima nuclear disaster. This was another place where students were guided into thinking about perspectives other than their own and understanding how many decision makers can affect the outcome of any scenario.

Once the students groups were ready with their deep dive, they would be expected to present their findings with the rest of the class. The students were expected to lead discussion on the ethical questions and learning and to ask if the class identified more biases than what the presenting group was able to identify. This way, for any given topic or incident, the entire class would have a multi-faceted understanding and analysis as presented by the different groups.

Another intentional benefit to having students present their work to the entire class was to give students motivation to dive deep into a topic and think of well-prepared questions as they had to take ownership of their slides when they presented. We know that wanting to seem well prepared

and knowledgeable among their peers was a bigger motivator than mere submission or participation grade. Being able to see other student groups make progress on their sections of the shared slides was also helpful in motivating students to not deviate from their goal.

Scenario creation

We favor the scenario-based approach in the classroom is described in Robey's paper[25] in which there are ethical dilemmas or scenarios that have already been used and evaluated in the classroom. These scenarios can be included in other similar tools and directly compared to the student-created scenarios in the same paper and non-student scenarios, for analysis. Another way to frame these ethical scenarios comes from the computing ethics literature survey by Stahl et al.[26] wherein the researchers emphasize the different aspects of ethical issues in computing that should be subjects of focus, namely: (1) Technology, (2) Methodology, (3) Ethical theory, (4) Contribution, and (5) Recommendation.

Based on some of these scenario based activities, we designed our own scenario based intervention in the classroom. We found that the scenario creation activities were the biggest contributor to having students understand their ownership and responsibility and the frequency with which they would encounter relevant decision making.

Students were routinely asked to create playable decision making scenarios made from the point of view of different roles. Their scenarios were related to the topics we discussed in the classroom. In each scenario, players would have to make multiple decision where they choose from a few options. The students did well to ensure that a lot of the scenarios pose real and relatable choices that sometimes all lead to unwelcome outcomes. This helps relay the notion that ethical dilemmas can be about small decisions and can have no ideal options. Where action, self preservation and inaction may all have unfavourable consequences.

Student developed scenarios were typically two to three decisions deep. Many of the scenarios helped examine the whether different roles would tend to have different biases. In figures 4 and 3, we share some select screenshots of the scenes and choices the user would be presented with, along with a few consequences or downstream choices.

After creating the playable scenarios using google forms, student teams were also required to present a block diagram depicting the overview flow of decisions in the scenario showing the scenes and the choices. This was an important tool in visualizing their scenario and allowed for another reflection point into the complexity of even seemingly simple decision making. We see examples of the scenario overview diagrams created by students in figures 5 and 6. This was meant to motivate the students to think of different pathways, choices and outcomes, realizing that sometimes unfavourable outcomes result even from seemingly sensible and ethical choices. The students were told to try to focus on the types of scenarios they conceive experiencing and not to surrender to one's tendency for outlandish scenarios which would tend to be more extreme and hilarious, however, they would miss the point of the exercise.

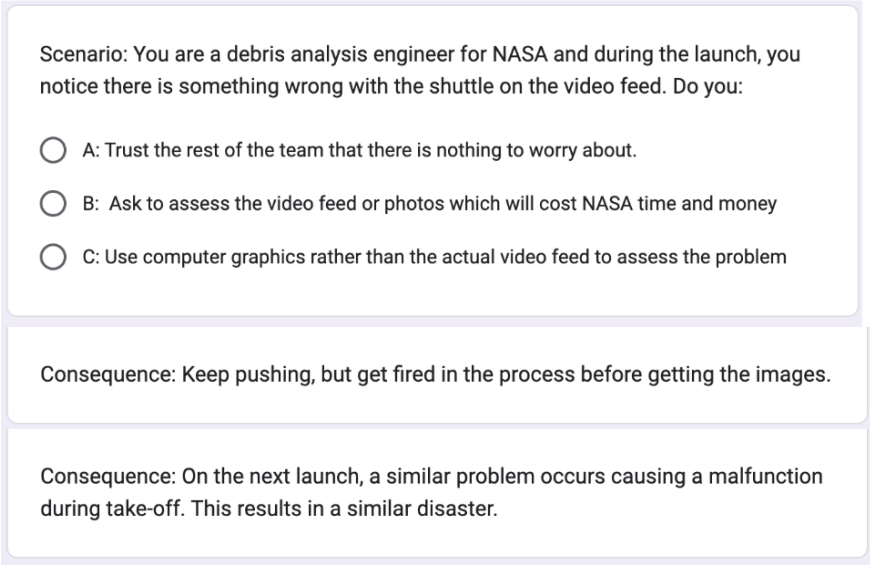

Figure 3: Screenshots of scenes from a student created NASA engineer scenario.

Scenario play through

After the student teams create their scenarios based on their assigned topics, they present the scenario to the class and play through the scenarios, prompting other students to share their choices. At different points, the instructor would ask students selecting choices to explain the motivation and thinking behind their choices and allow for discussion on the differences in choices for different students, often trying to identify what biases are likely to affect the person in the role they are attempting to embody.

Then the team who created the scenario would play the choice to the next scene and would pause for more discussion. The collaborative playing of the scenarios led to some deep conversations about how one might behave when faced with such challenges. We also discussed whether that behavior would change if the person in that role is encountering that issue for the first time or if that type of dilemma was one they saw often in their work. We discussed how prior experience would affect their decision making, considering biases.

Often after one play through of a scenario, we would ask the class to go back and try a different pathway through the scenario, until most of the pathways are exhausted. It helped refocus the conversation on the roles and their biases in the moment of decision making.

Group Debates

Occasionally, the students groups would be asked to participate in a debate on an assigned topic. Apart from the two debating groups, another group would set rules for the debate and another group would be required to moderate it. This led to some of the most memorable and hilarious classroom moments as teams came up with often absurd and challenging rules for the debating parties.

In one instance, a rule was made that the team could only answer a question by speaking one

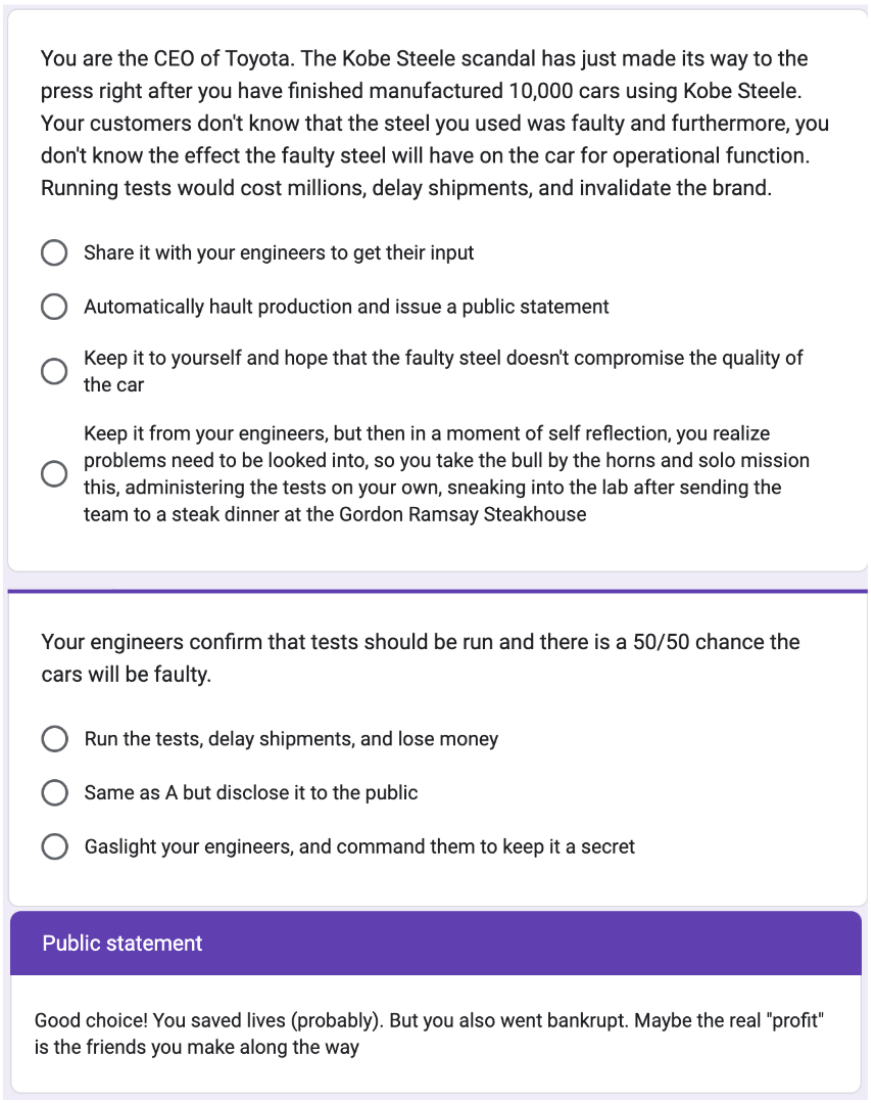

Figure 4: Scenes from a student created steel quality defect scenario.

word per participant, going back and forth till sensible sentences are formed. In another instance, debating teams were told that they can only make arguments while hopping on one leg, and switching legs at the start of each new sentence, so that their arguments remain short.

The debates added fun and hilarity to the class, especially when the topics being debated were heavy and sometimes dark. They also helped break up the monotony of listening about disaster after disaster and to force students to have to think about the same issue from multiple perspectives. Some of the debate topics were designed to lead students to inhabit a role and defend their decision making in that role and based on that context.

Final project - analysis of a topic from a chosen branch of engineering

Students formed pairs for the final project, which was designed to help students practice using the tools they have learned in the semester - biases, ethical frameworks, roleplaying scenarios. This

Figure 5: A student made scenario on government corruption.

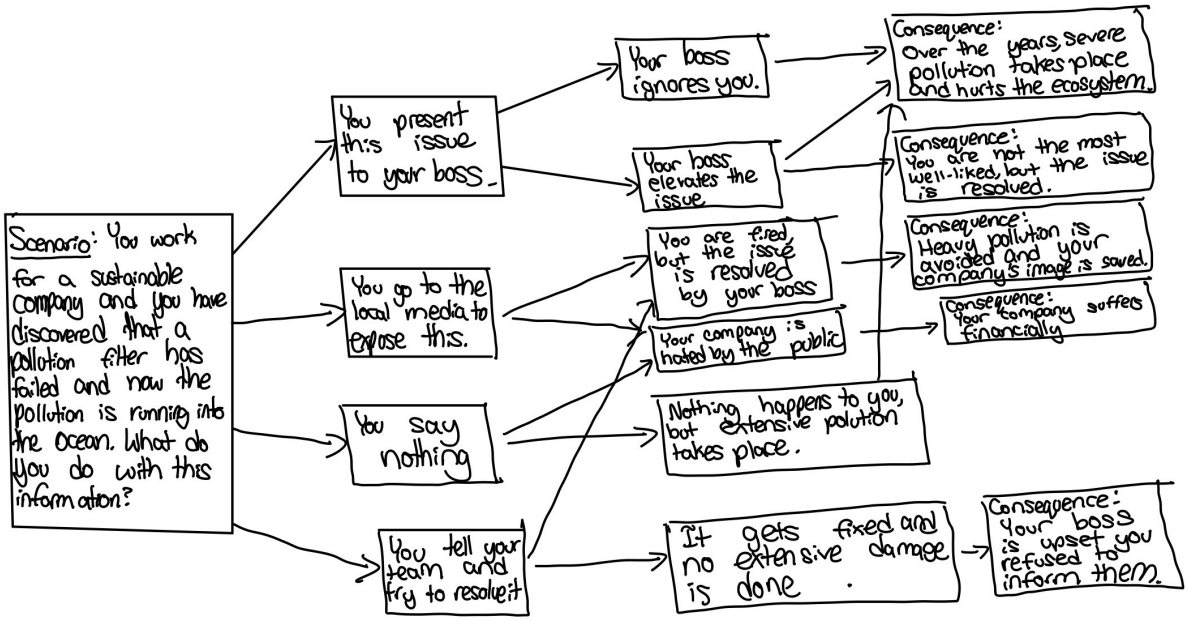

Figure 6: A student made scenario on environmental action.

final project was meant to help students practice their frameworks and bias analysis to look at whole fields, not focusing on just one aspect of a type of disaster or issue.

The students were free to choose a branch of engineering to do a deep dive that examined ethics based concerns in that particular field, do a deep dive on the selected topics (including examining decision making biases) Students then develop suggestions for some long term changes that could help prevent such incidents. Students were also expected to discuss some long running pervasive concerns regarding the practice of the field, e.g. the cost of clean energy on the environment, etc. Students were expected to describe some short-term and long-term steps that the field should take to affect change.

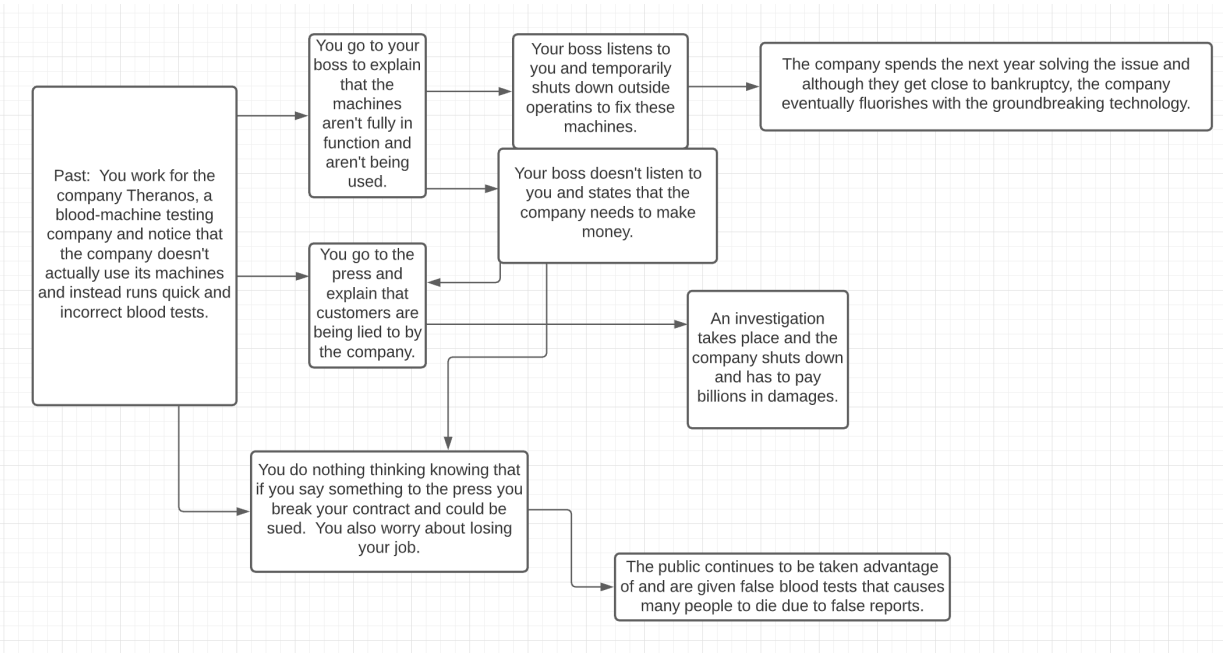

Figure 7: A student made scenario on corporate conscience.

Other course activities

We describe some activities in this section, which are not necessarily novel, but were repeated points for reflection. The course also employed regular individual written reflections and collaborative article reading. Students were given specific prompts to reflect individually on some major topics. The questions were guiding to enable student reflection on their personal values in light of other frameworks.

We used the reading tool Perusall for collaborative reading. The readings would typically cover detailed stories or news articles pertaining to the details of the current topic. The collaborative nature of the readings helped foster conversation about the ethics topics before students even saw the topics in class. This helped seed the topics and increased the time spent mulling over a topic.

Elective Ethics course

In this section, we share some sources of case studies and other material that has been seminal to our course design, we then describe some select activities from the course. This was an elective, writing intensive course with a class size of about 28 students.

A foundational piece that helped shape our activities is the set of case studies from Giving Voice to Values from Mary Gentile[27]. These begin with the assumption that students know what the right thing to do is, but won't always know how to make that happen at work. While the Giving Voice to Values cases were initially developed for business ethics students, several cases have been created for engineering students. We found that a great primer for an ethics discussion is the Tale of Two Stories exercise from the book. Other cases we've used and found extremely fruitful are: Move Fast but without Bias, Reasons, and Rationalizations Exercise, Ubiquitous

Surveillance, Who's my Boss, and You Can't Tell Anyone. These work well when given to students in a small group to discuss, then debrief as a whole class.

Another resource that helps general engineers thinking about ethics is Bowles's Future Ethics[28] which talks about social and ethical implications of design features, especially digitally. A very clear and accessible text, but brings in the key thinkers for tech ethics. We also used the book Ethics of Invention by Jasanoff[29] where she talks broadly about the social/political/legal actors at play in the tech ethics space. This book focuses more on a cultural/historical understanding of the major events that had ethical outcomes. These two are great to use in class, we typically assign the first three chapters of Future Ethics and the introduction of Ethics of Invention in a unit on the philosophy of technology. Together these provide a great philosophical (Future Ethics) and historical (Ethics of Invention) introduction to tech ethics for any engineer.

Tech Ethics in the News

Every Tuesday we open class with a unit called "Tech Ethics in the News" this part of class is an open time in class for students to bring in any interesting articles they've seen online in the past week. If the news piece is more technical, we ask the students to share how this is connected to ethics. Then we give other students the chance to respond or raise new questions, leading to a 10-15 minute discussion. Since this part of class is weekly, the students know to prepare and bring something to class. One example of this is that last semester we discussed FN Mika a virtual rapper who had been dropped by his record label for using the N-word in his song. This led to a discussion about AI-led projects and a student even wrote his final paper about FN Mika and virtual celebrities.

Dialogue Groups

This course requires students to meet with small groups (4-8 students) for about an hour outside of class time to further digest the course material. This allows the students time and space to explore the topics from their own perspectives. They are guided to learn how to hold a dialogue (versus a discussion) and every student is given a role within the group to again have ownership of the discussion. To prepare students for this outside-of-class meeting we follow the dialogue guide as prepared by the "God and the Good Life" course at the University of Notre Dame[30].

Podcast Assignments and Assessment

Another activity of the dialogue groups was the creation and submission of a podcast episode. Students were given the pitch to answer the following question: What are you most concerned about in the realm of technology ethics? And asked to have a conversation around this in the format of a conversational podcast.

This allows students to bring in their own interests to the classroom. For assessment, they are assessed on the following questions.

1. Creativity in addressing the prompt: did you use a variety of sources?
2. Did you take a topic and introduce it at a level that a general audience could understand?

3. Style and creativity with production (formatting and polish). While significant editing is not necessary for a good podcast, were you prepared for the conversation/interview?
4. Did you teach me something new or have me consider an interesting perspective?
5. Did all the group members participate? (cite the contributions of each at the end or in the episode notes)

This assessment rubric is used to gauge creativity in approaching the assignment. It doesn't assess the subjective nature of the content but rather asks questions like, "Did you teach me something new or have me consider an interesting perspective?" to assess whether or not students just drew material from class or went deeper looking for topics and framings from their independent research. The best podcasts included a discussion of technology from the first person alongside a deep dive into corresponding social/cultural/empirical insight. This approach combines the subjective experience of the student with some more objective thinking to add depth to their unique experience. This type of assignment allows students to explore and take ownership (having to teach me something new) while also encouraging good practices like creativity in topic and production value. Assignments like this allow students to control the conversation while learning how to consider ethical scenarios.

Non Ethics course - Ethics website

Everyday ethics

Through discussion with faculty and students we established that one pervasive concern is that a lot of engineering and computing ethics discussion appears distanced from the lived realities of the lives young engineers would face. We find that ownership of and visibility to realistic situations where simple decisions have an ethical question or impact is vital to providing that ownership. To serve this, we started the task of working with students to help build this.

On the landing page of the tool, players could select which scenario they wish to play, see figure 8 for a screenshot of that initial team's ethics tool's landing page. The general idea was to have a tool where there is ethics engagement through immersive scenarios and roleplaying, just as we they have been used for learning in the classroom.

Over the years, we engaged different teams of students in senior level elective software development or software engineering courses to design and build this tool. The iterative user interaction and interface design was another intentional opportunity to engage engineering students in thinking about engineering ethics and how they could be presented. The first team of software development students working on the tool also developed their own metric for giving the player of a scenario a report that assessed how their decisions fared against a set of virtues and based on their decisions, which ethical framework are they most likely aligned with.

Figure 9 shows an example of a scenario results page, where the decisions made by the player have been rated on the student developed virtues metrics. Figure 10 shows the second part of the same result where the player's choices have now been mapped to their match with different ethical framework buckets.

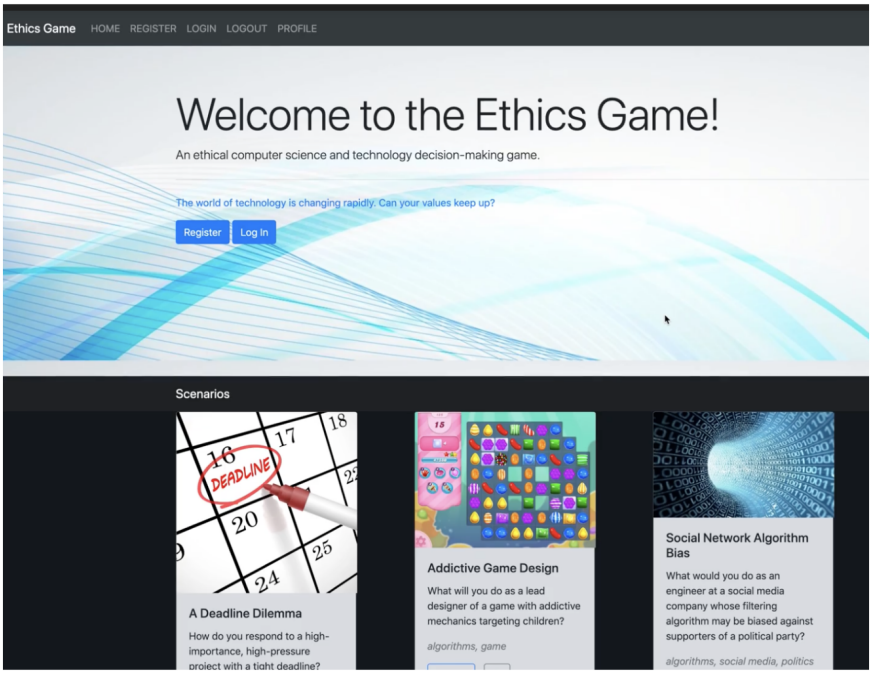

Figure 8: Student developed ethics tool landing page where players could select which scenario they want to play.

Even though there can't really be objective ways to create such metrics and mapping calculations, the fact that the student group spent time trying to develop these metrics and their underlying calculations, is in itself a point of deep engagement with the topic of engineering ethics.

In subsequent semesters, different computing student teams from senior level elective courses like software development courses and from computing service projects courses continued the work to add more features to this initial work and then to redesign the tool entirely. As the student teams were developing the ethics tool, we organized multiple scenario creation workshops where computing students from different upper level courses would build or design some of the multi-decision scenarios we now use in the ethics classroom.

Challenges with classroom interventions

In considering the classroom interventions, there were several challenges worth highlighting. The first is that there is a particularly broad spectrum of political orientations of students at the University of Notre Dame. This necessitates an increased level of trust building among students to enable them to feel safe enough to share their perspectives. We need to foster psychological safety in the ethics classroom. Norms building at the beginning of the semester is especially important for setting fair and explicit rules, such that students know how to enter group dialogue.

As instructors, we were careful to try to model through demonstration, not just how to assess existing case studies and engineering disasters but to also give students the tools and framework to be able to assess cases and situations they have not seen before. To this effect, at certain points, we intentionally had space for students to bring any ethics topics they would like to discuss and then we tackled that new case using the frameworks. This aligned with our goal to give students

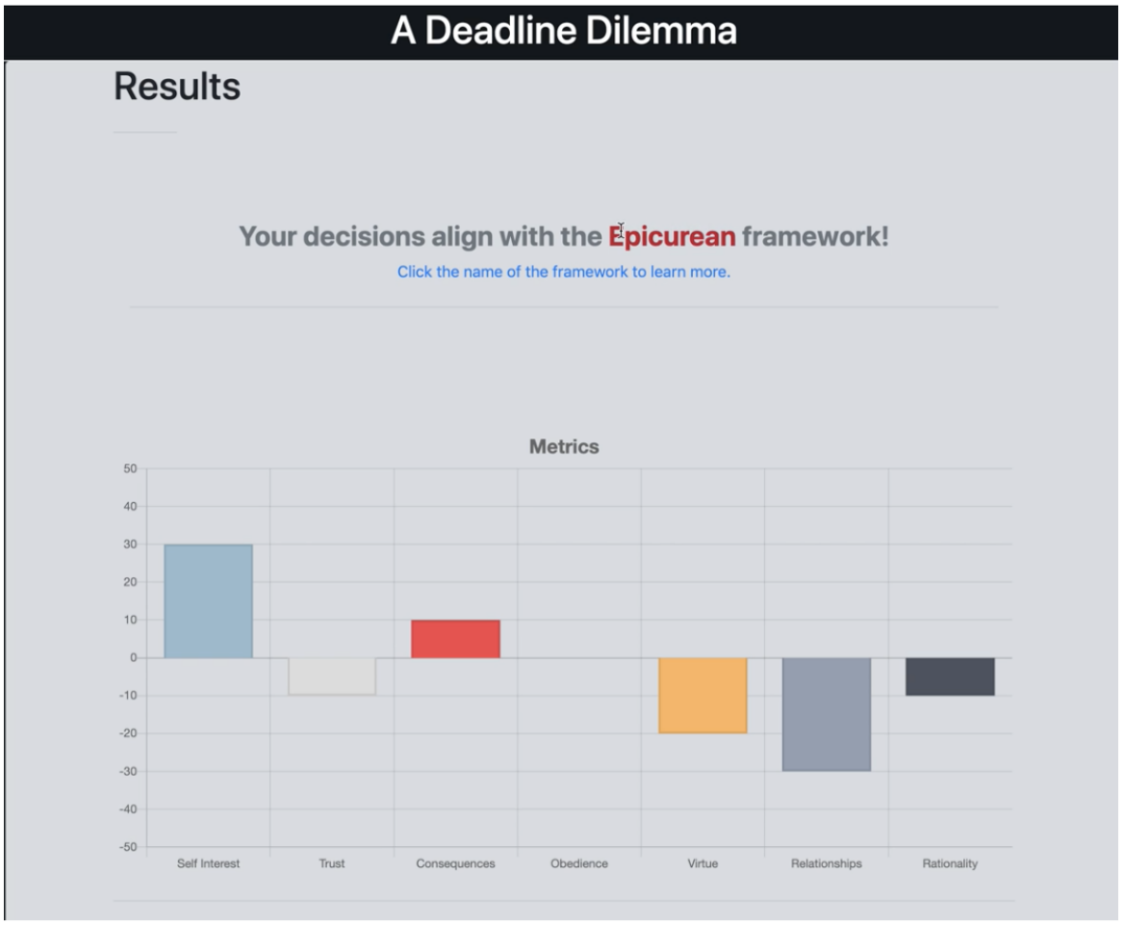

Figure 9: Student developed ethics tool results where player's decision making is rated on virtues.

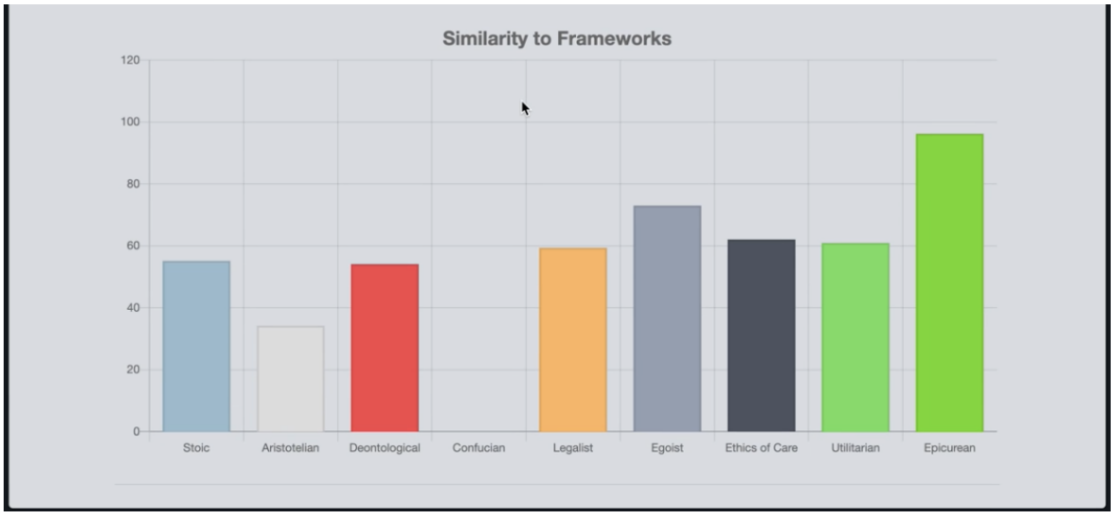

Figure 10: Student developed ethics tool results where player's decision making is mapped to ethical frameworks.

the tools they need instead of stock answers. It was also important to demonstrate that the

discussion of ethics comprises not having obviously correct questions and answers, but to have a space and language to discuss topics that are unfamiliar and then have some means to approach unfamiliar topics. This is something we have tried to do and are going to try to continue to do. We had be to especially conscious of this when we would guide students to create scenarios, so as to allow for realistic outcomes, which may not always be ideal. This took some practice for the students to understand that they are not looking to find good and bad options, but to really try to situate themselves into a role and think about reasonable biases and corresponding actions that people would take.

Another aspect we had to carefully and actively monitor is classroom participation by incorporating accountability for each activity. This was not necessarily part of the original activity design, and some of it was necessitated by the large classroom, where it would be easy to hide in a large group where others do all the work. Each group had to be assigned work that can be split into five to six members, without anyone having too light a load. As we have seen in other courses, bored students become disengaged students. This was something we anticipate having to adjust for most classes, based on the student commitment, engagement and attention span.

Aligned with Bloom's taxonomy, we certainly found that having the students present on different topics to each other through active learning and other collaborative learning approaches was far more effective than if the same material were delivered in traditional lecture. It was essential that students were the ones creating, applying and assessing meaning, instead of being given comprehensive analyses as a passive observer or consumer. This often meant that the same lecture material took longer to cover, but we observed that the engagement was considerably better. This was a difficult trade off, as our initial instinct was to try to use class time to cover far more topics than the slower exploration, analysis and synthesis that students would produce. However, the trade-off with deeper student engagement justified our intervention choices.

Assessment of ethics based interventions

In order to help students explore ethical issues, there have been many tools, methods, and tests created and evaluated to help quantify the qualitative aspects behind ethics and subsequently, the study of it in computing. Several attempts to design tools to assess ethical attitudes have been made by different researchers. In his paper on Ethical judgements and behaviors[31] , Jung provides another style of assessing ethics in a questionnaire design approach conveying 16 steps or recommendations. The questionnaire is meant to elicit ethical attitudes but primarily towards negotiation situations. Their survey used was based on the Self-reported Inappropriate Negotiation Strategies Scale (or SINS Scale) developed by Robinson et al[32]. Furthermore, this questionnaire can potentially be adapted and used to explain metric rubrics for similar assessments.

In his paper on the ethics of computing, Weiss[33] provides a self assessment instrument that has different scenarios, each of which has a different score depending on the participants opinion: (1) Unethical, (2) Not Unethical, and (3) No Ethics Issue. The paper systematically breaks down its own unique scoring system and also explores general principles governing each scenario. In a completely different approach, the paper by Applin that focuses on a learner-centered approach[34] details a university-level course on ethics structured around this approach that assists students in

remedying ethical issues in the field of computing, building emotional intelligence to respond appropriately to these issues, and overall, become more aware of the ethical implications and their underpinnings in computing.

In this paper, Applin shares the tale of the two hackers, an example of multimedia content with a written reflection and a learning style assignment that shows a straightforward approach in assessing students on the topic at hand. Scenarios are a useful approach in testing ethics, however, the scenarios themselves may need rubrics that assess their effectiveness in achieving their goal. The paper by Pearleman et. al[35] on assessing the quality of ethics case consultations provides a table that has an assessment rubric for a diverse set of questions and scenarios, each of which are related to different topics of discussion and can potentially prove to be useful in rating the relevance of new scenarios.

In searching for the right assessment tool for our goals, we found that some great tools exist out there, but none that capture the effectiveness of our methods towards our goals. Considering that the overarching goal of this work was to engage students beyond the surface level, we have been searching for effective means to assess the internalization of ethical thinking. Ideally, we would assess these in post hoc reflections some years after the course, when students have had industry experience. They could then reflect on whether our courses have helped them be more keenly aware of their ethical responsibilities in their careers. As part of the course, students were engaged to explicitly and repeatedly discuss the roles and responsibilities of engineers.

We began piloting these courses three years ago. So, our oldest cohort of students are still in their undergraduate studies or have graduated within the last year. Given that we cannot yet assess the long-term career impact, we have looked at other means of assessment.

Another track would be employ an already validated ethics measurement instrument that has been used in computing or engineering ethics courses before. Upon a seemingly long search, we found some instruments that come close, but do not capture the general aspects of student engagement and a sense of personal responsibility that we are aiming to affect.

The summer Ethics in Engineering courses were assessing student submission based on whether they doing everything in their assignment prompts and how well they were doing so. We spent a lot of time designing the prompts to force students to cover a comprehensive analysis inspecting different aspects of the assignment topic. It also helped that we asked students to present their assignment work to the class, as students preferred being thorough before having to share their work.

Anecdotally, many students shared that learning through the scenarios, frameworks, bias, and roleplaying helped them understand how important these ethics issues are and how they are likely to encounter them.

REFLECTIONS AND RECOMMENDATIONS

Reflecting on this project we have several specific recommendations to offer other instructors looking to implement or looking to improve their pedagogical techniques while teaching ethics courses.

1. Audience-specific, motivation and comfort driven activities

Over the course of the last several years, our biggest realization in the process of integrating ethics in the engineering curriculum is a fairly obvious one - know your audience. We found, through trial and error over multiple semesters that the amount of intrinsic versus extrinsic motivation for the participating students made a significant difference in how we would design and administer the activities.

For the summer Ethics in Engineering course, where students enrolled in study abroad had to enroll in what would otherwise be an elective course, we found that we had to carefully design towards motivation and accountability. We know from previous experience that for many engineering students, working with subjective topics like ethics can feel uncomfortable, uninteresting and ”outside of engineering.” We had to ensure that we configure the vocabulary, frameworks and rubrics in the course to be things that students see as scientifically validated and categorized concepts e.g. cognitive bias and technology bias.

We also had to be careful to ensure we provide detailed and objective prompts for any deep dive that we would ask of engineers, especially those engineers who may only have extrinsic motivation to engage in the topic. We know that most open ended questions without more detailed sub-prompts would otherwise receive minimal answers. The point of the prompts was to design their journey of the deep dive.

It was important, for this audience, that we start the deep dive with objective answers, e.g. for some case studies, we had students collaborating across teams to build a detailed timeline of events that led to a disaster. This task would help students get interested in the event itself, and then prompts that followed would have students trying to identify decision making points, decision making roles, etc. to try to anchor their responses. We also found that the bias and ethical frameworks language helped students think about an issue from perspectives often quite antithetical to their own personal beliefs. In our prior experience, we would observe disinterested or uncomfortable engineers hoping that others would voice their opinions enough to not warrant everyone having to share. This was no longer the case for our redesigned activities.

In contrast, the activities designed for the students taking the elective Technology, Self and Society course were different. The students came prepared to share. Here, it was important to foster an environment where being vulnerable and sharing personal opinions was possible. We were able to engage more closely with having students examine their personal values and relationship with technology and society. We did not have to have intentional layers of abstraction to distance students from the current topic, to facilitate examination and discussion.

2. Scaling to large classes Another piece that was helpful was having students work collaboratively to gather responses to present to peers, instead of just individual submissions. That motivated students to be thorough and engaged. However, this was also a challenge in a large classroom. When group sizes were large and there were often ten groups to present on different aspects of the same topic, it started to feel slightly repetitive and tiresome. Some strategies for helping with that tedium are to have all groups prepare but only have some groups present. Collaborative readings with Perusall were a way that all students could comment and read together, even in large classes. When the students would work to present slides to the class in the Ethics in Engineering course, we used Google Slides to have the entire class collaboratively

edit and update the slides. We would section off specific slides, often identified by color, so that all groups only edited their assigned slides, but everyone could see all the edits made by all students. They were encouraged to look at the resources and references that other groups used, as it may inform their presentation as well. This helped motivate students to work to prepare good slides as they could see their peers making progress in real time. However, having over sixty students edit one document at the same time came with challenges of lag.

3. Most effective activities For the Ethics in Engineering course, we found that the scenario creation and bias frameworks were the most effective in having students roleplay and situating oneself in engaging with the topic. If you were to choose one intervention to start with, we would recommend the collaborative scenarios, as they were most effective. We would also recommend making a few changes at a time, and not all at once. We refined our activities over a few years, as we learned how to work out their kinks.

Returning to the main challenges of ethics education for engineers

At this point, we want to return to the main challenges outlined in the introduction. As one considers ethics education for engineers the main challenges of time, expertise, and application have been explored throughout this paper. Here we respond to the central concerns:
1. Lack of time: We acknowledge that lack of instructor time to design and try new interventions. This is why we have organized this paper to highlight our approaches to ethics education with different levels of interventions that expect varying amounts of lecture time availability. The ethics website tool allows instructors to send their students to interact with existing student-developed ethics scenarios. Students can choose to play, analyze through the overview diagram, and the create scenarios. An instructor can design an interventions that happen entirely external to lecture time, or include playthrough and reflection activities within their lecture, without needing to build anything for the activity.

We also share the resources we found were useful tools in the curated resources section. These have saved a lot of time and rework in developing new content. Comparing ethical thinking to design thinking can help build on what the students already know and are comfortable with.
2. Feeling like not an expert in ethics/ don't know where to start: This was a common concern with the Virtues and Vocations working group at the University of Notre Dame. One way to respond to this is to find a few key resources to start, and to invite the students into the discovery process. Students respond strongly and positively when instructors admit they are not experts and invite the students to look for answers themselves. As these students move into the workplace, they will be confronted with ethical questions they don't know the answers to so teaching them about the discovery process is essential to set them up for their future roles. As technology will keep advancing at a maddening pace, it is less important to have the answers and more important to know how to ask structured, deep questions in an informed way.
3. Ethics formation happens outside/before college: We acknowledge that, students are entering the classroom with some preconceived notions. And that for the most part, they know how they should feel or react in a situation. In response, first, the work we do in the classroom is not a complete introduction to the academic field of ethics, but rather a sensitizing of the students toward the idea that their engineering design decisions can and likely will have social, cultural and political impact. For this reason, we again focus on the process of confronting and reflecting

deeply on ethical scenarios from the development, implementation, and use of technologies. Second, the 'Giving Voice to Values' approach of Mary Gentile, proposes a new way of teaching practical ethics classes. Gentile says that your students probably already know what the right thing to do is, but they don't necessarily know how to make that a reality. By flipping ethics education on its head, her approach starts with a goal in mind and works backward to think through the act of acting ethically on a team. Together these approaches draw on the formation students have before they reach the classroom and teach them skills to see when ethical impacts may arise and begin learning how to communicate that with colleagues and team-mates.

Future Work

Looking to the future, this project will continue on through a working group of about 20 faculty at the University of Notre Dame who all incorporate virtue and ethics into either their research or classroom work. As this group continues to meet, we will draw from the resources developed by undergraduate students advised by Dr. Levis and Dr. Kumar. We will continue to seek out quantitative and qualitative means to assess our interventions and will continue to see out collaborators in our journey to strengthen the ethical education of engineers.

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