Work in Progress: Toxic Workplaces: Game-Based Exploration of Engineering Ethics for First-Year Engineering Students

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This Work-in-Progress paper stems from an NSF-sponsored project in which a series of game-based activities have been developed for the purpose of enhancing instruction in engineering ethics. These activities have been integrated into first year engineering courses on several campuses. One of these activities is called Toxic Workplaces. In gameplay, the students are presented with scenarios that involve ethical dilemmas. Each scenario comes with several possible responses. The game involves the student/player attempting to rank these possible responses in order of popularity. Thus, players do not necessarily need to take a position on what they themselves would do, but rather are attempting to match the results of survey data that was collected previously.

In the Fall of 2022, a team of eight undergraduate students completed a project in which they developed new scenarios, greatly expanding the range of options available to an instructor who wishes to incorporate Toxic Workplaces into a course. This paper describes the game itself and its motivation, and discusses the process by which the undergraduate student team generated and refined their new scenarios.

Introduction

Ethical decision-making is a significant aspect of engineering practice. The importance of addressing ethics in the undergraduate engineering experience was highlighted by a study in which senior engineering students, reflecting on their ethical and moral development, reported their familial and academic experiences as being their most formative [1]. Indeed, one of the effects of the updated ABET criteria implemented in 2000 was to call increased attention to engineering ethics in the undergraduate curriculum [2]. McDonald noted that while virtue specifically cannot be taught, and must be wanted on a personal level, the ability to make ethical decisions is distinct from (though related to) virtue and is a skill that can be developed [3]. In 2005, Dyrud [4] emphasized the importance of ethics in engineering education, and described how it can affect performance both in later courses and in future careers. Harris and co-authors [5] recommended that ethics should be introduced as early as possible and as many times as possible, both in introductory and technical courses.

Various strategies for approaching engineering ethics instruction have been proposed and implemented. Carpenter [6] discussed framing ethical decision-making through a mathematical lens such as optimization theory. Reeves and Nadolny [7] outlined using virtual simulations of ethical dilemmas to better teach engineering students about ethics. A literature review conducted in 2018 [8] concluded that the most effective ways of teaching and retaining engineering ethics to students involved case studies, introduction of specific ethical codes for engineering organizations, and discussion-based activities. Banik [9] outlined the use of case studies specifically in regards to the AEC (architecture-engineering-construction) industry, and discusses the benefits of doing this when students graduate into industry. Harris and co-authors [5] noted that relevant case studies could take the form of either newsworthy events or smaller, low-profile

scenarios that introduce students to ethical dilemmas they might encounter in their careers. The current paper shares the goal of using realistic situated experiences such as case studies for engineering education, and specifically explores game-based interventions.

Gamification is a pedagogical strategy that has been implemented across a range of settings. One example [10] was a gamified learning approach to introducing a library orientation tool that many engineering students had to use. The approach was found to be linked to an increase in proper source citing and use of other library resources. Instructors in a multidisciplinary introductory engineering course at Rowan University replaced traditional homework with a gamified system that involved earning points through completion of "quests." [11] Application of game-based learning to ethics specifically was described by Dyrud [12], who discussed the use of ethics training games in engineering-oriented businesses. It was concluded that scenarios based on real life events had a greater impact on employees and students than hypothetical ones created specifically for the purpose of the game. The strategy of adapting scenarios from real-life events was used extensively in the present study.

This paper stems from an NSF-Sponsored project in which gamified interventions for enhancing engineering ethics instruction have been developed and integrated into first-year, multidisciplinary engineering courses at several universities. [13] Specifically, the three activities are:

- *Cards Against Engineering Ethics*, in which black cards contain a sentence or passage that includes a blank, and white cards contain words or short phrases. A black card is played and then players choose white cards with which to fill in the blank. This is the same gameplay mechanic as the popular game *Cards Against Humanity,* but the cards are specifically intended to relate to engineering study and engineering practice.
- *Toxic Workplaces*, in which a scenario that involves an ethical dilemma is posed, along with a range of possible responses to the scenario, and student players then propose a rank order for these possible responses.
- *Mars: An Ethical Expedition*, a "Choose Your Own Adventure" style game in which players choose how to respond to situations that occur in a recently established Martian colony, and their choices can impact things that happen later in the story.

This paper discusses the development of new content for the Toxic Workplaces game.

Toxic Workplaces – Game Play

In Toxic Workplaces, the game players are first presented with a written description of a scenario that involves an ethical dilemma, which is typically between ¾ page and 1½ page in length. These can be inspired by real events or completely contrived, but are intended to be representative of dilemmas that an engineering practitioner or student could plausibly experience. Examples include:

- "Oh-No Rings". This is a scenario inspired by the Challenger Space Shuttle explosion in 1986, but the scenario is positioned in time before the launch, and is written from the point of view of a low-ranking NASA employee who has concerns about the safety of launching in cold weather.
- "To Flush or Not to Flush". This scenario is written from the point of view of an engineer who has collected data on pollutant concentrations in groundwater, but the day before the engineer is supposed to present their report to a state regulatory agency, the engineer learns that someone else has probably been tampering with the results.
- "The Plagiarized Proposal". This scenario is written from the point of view of an engineering contractor who submits a proposal and cost estimate to a potential client. The contractor later learns that the client is following that exact proposal, but has hired a different contractor to do the work for a slightly lower price.

After reading the scenario, the players are presented with a set of cards, each of which gives a possible response: typically, 4-7 different actions that a person could take in that situation. The instructor reveals to the players that a cohort of engineering students was surveyed previously on how they would respond to the scenario, and that the responses in front of them came out of that survey. The game players are then tasked with predicting the popularity of each response and sorting the response cards from least popular to most popular. Thus, the players are not simply deciding what they themselves would do in the situation, they are considering the merits of every possible response in comparison to every other possible response. This gameplay mechanic is somewhat reminiscent of the TV game show Family Feud, in which players try to predict the most popular responses to a survey question. The gameplay rules work the same whether each student is playing individually, or whether each "player" is actually a small group of students who are discussing among themselves and producing group responses. This activity can also be implemented either in real time during class or as homework.

After the players make their ranking, the instructor reveals the actual percentage of survey respondents who chose each response. Some instructors might consider it unnecessary to assign numerical scores to the players' predictions, but if the instructor chooses to assign scores and determine a "winner," this can be done as follows:

- Each player arranges their cards with their predicted "least popular" response on the left, and then increasing in predicted popularity from left to right.
- If the player's leftmost card does in fact have the lowest percentage, the player receives one point.
- The player then moves from left to right and checks each card's actual popularity against that of the card immediately to its left. For each card that had a percentage response equal to or greater than that of the card to the left, the player receives one point.

Thus, the maximum number of points for a scenario is equal to the number of responses.

The game-play experience, whether it is followed by "scorekeeping" or not, can then be used as a launching point for class-wide discussions of ethics and ethical decision-making.

Fall 2022 Content Creation Project

The Toxic Workplaces activity, as described in the previous section, has been integrated into first year, introductory engineering classes at several different universities [14]. The number of different scenarios that had been used prior to the start of the 2022/2023 academic year was less than 10. During the Fall 2022 semester, a team of eight junior and senior engineering students representing four different engineering disciplines (Electrical & Computer, Mechanical, Civil, Chemical) participated in a project in which the students authored new scenarios for use in the Toxic Workplaces game. The project was integrated into the Junior/Senior Engineering Clinic, a two-credit project-based course that is required for students in all engineering disciplines at Rowan University.

The goal of the project was not only to expand the range of options available to the instructor, but also to broaden the range of courses for which Toxic Workplaces is well suited. Thus far, Toxic Workplaces has only been used in introductory engineering courses that are multi-disciplinary in nature. In this context, most any scenario that included a compelling ethical dilemma would be suitable. However, engineering ethics instruction also occurs in disciplinary engineering courses. The student team's goal was to ensure that the bank of available scenarios would include at least 3-4 that were clearly related to each of the engineering disciplines, so that they would seem more relatable to students taking a class in that discipline. In all, 24 new scenarios were crafted, with each student on the team serving as the primary author of three.

The workflow of the project was as follows. The team met with the faculty project manager (PM) weekly. During the first week, each student came up with a list of possible topics for a scenario. The PM then had a dialogue with each student about these ideas. Two primary considerations in these conversations were how to craft a compelling ethical dilemma within the topic, and ways in which the topic was complementary to and/or potentially overlapping with ideas being pursued by other members of the team. In the second or third week of the semester, each student committed to one topic and started writing it, while also continuing to dialogue with the PM about possibilities for their second and third scenarios. Scenarios were written iteratively with continuous feedback from the PM and from other team members as needed. The goal was for the three scenarios to be completed in approximately the fifth, eighth and eleventh weeks of the semester, but these were not treated as firm deadlines.

Once the PM and the student author both considered the scenario "complete," it was moved into a google drive folder entitled "Scenarios Ready for Responses." Each member of the student team read each of their teammates' scenarios and provided a response stating what they thought the main character should do. The primary author of the scenario then compiled these responses, combining similar responses and eliminating duplications, to produce a first draft of the list of possible responses.

Outcomes From Fall 2022

The student team produced a total of 24 new scenarios. As noted in the previous section, a goal of the project was to produce a variety of scenarios that included representation of a variety of engineering disciplines. Table 1 shows the topics of 20 of scenarios in which the main characters are engineering practitioners, and also shows the engineering disciplines to which the team considers each scenario connected. The other four new scenarios each occur in an academic setting. Three are written from a student perspective, and involve potential cheating on a final exam, plagiarism of a major paper, and dealing with a teammate who is perceived as not fully contributing. The last is written from an instructor perspective and involves handling student requests for accommodations.

Table 1: Mapping of Twenty Scenarios to Related Engineering Disciplines

Topic	Mechanical	Electrical	Chemical	Civil	Environmental	Computer	Biomedical
Semiconductor Shortage		X				X	
Sand Shortage		X	X		X	X	
Addictive Software Design						X	
Baby Powder			X				X
Phone Battery	X	X					
Airplane Navigation	X					X	
Stadium Collapse	X			X			
Hoverboard	X						
Car Safety	X						
Site Remediation			X	X	X		
Customer Satisfaction	X						
Biased Mediator				X	X		
Copyrighted Code						X	
Systems Engineering				X			
Hotel Bridge Building	X			X			
Fortunate Son				X	X		
Flawed Computer Chip		X				X	
Radiation Treatment Therapy						X	X
Faulty Assumptions				X			

In addition to a variety of engineering disciplines, the bank of new scenarios is also intended to offer a variety of contexts. In many of the scenarios the main character is accountable to a boss and the boss' opinion is a consideration in the dilemma. One such example is "Customer Satisfaction," in which the main character has been asked to repair a bicycle to the customer's exact specifications, but she considers the specifications to be inherently unsafe. In this story the fact that the main character is at low-ranking recent hire at the company is an integral part of the scenario. In other scenarios, the main character is the ultimate decision-maker: being accountable to a specific boss is not part of the scenario, but this also means that simply following some else's instructions is not available as an option. Another distinction in which the team strove for variety is the stage of a project at which the dilemma occurs. For example, several of the new scenarios involve product development at various stages:

- "Radiation Treatment Therapy," "Car Safety" and "Hoverboard" center on products that are still in development
- "Flawed Computer Chips" and "Phone Battery" center upon products that were recently released and turned out to be problematic
- "Baby Powder" involves concerns about a product that has already been on the market for many years.

As another example, "Hotel Bridge Building," like the "Oh No Rings" scenario that has been used previously, is based upon a true event, but is positioned in time before the disaster has occurred. The main character suspects an unsafe situation is developing and must decide what if anything to do about it. By contrast, "Airplane Navigation" deals with the immediate aftermath of a disaster.

Each scenario is accompanied by a proposed list of responses, generated by the Fall 2022 Clinic team. Before the new responses can be used in the Toxic Workplaces game as described in the previous section, survey data ranking the responses must be collected.

Spring 2023 - Collection of Survey Data

Twenty-four new scenarios for Toxic Workplaces have been developed as described in the previous section. For these to be used as described in the Game Play section, there must be accompanying survey data quantifying the popularity of each possible response. The collection of this data started during the Spring 2023 semester and was integrated into multidisciplinary first- and second-year engineering courses at Rowan University, University of Pittsburgh and University of Connecticut.

Students at University of Pittsburgh and University of Connecticut are participating in this activity as homework. The 24 new scenarios and the proposed responses were formatted into a Qualtrics survey. The survey was programmed to choose 5 scenarios at random and present these to the student respondent. The respondent simply then selects one response to each scenario. Thus, from the student's perspective, it was not exactly the same experience as playing Toxic Workplaces as designed, but it was still an immersive experience in ethical decision-making.

Students at Rowan University participated through an in-class activity during the first week of classes. The instructors distributed two scenarios and the students used a google form to enter their responses. The google form response had two steps for each scenario. First, the student was able to type into a text entry box exactly what they thought they would do in the scenario. Second, the list of proposed responses was formatted as a multiple-choice question and the student would select one. It was found that some students skipped the text entry box entirely while most entered something that was substantially identical to one of the responses that was already on the proposed list. None of the ~100 students proposed anything that wasn't already represented on the list of options.

It is expected that at least some of the scenarios will need further development. While data collection is ongoing, it is already evident that for some scenarios, there are 4-5 different responses that are chosen with significant (though varying) frequency. This is an ideal outcome for playing the game as intended, since the student/player's main task is to predict the order of popularity of the responses. There are other scenarios in which the data collected to this point show one overwhelmingly popular response, or that show two popular responses with three other alternatives that weren't chosen at all. Such data sets are less useful for playing the game as designed. More fundamentally, such data sets suggest the scenario is not as compelling of a dilemma as it was intended to be.

Summary

Game-based interventions intended to further engineering ethics instruction have been incorporated into introductory first-year engineering courses at several universities. One of these interventions is Toxic Workplaces, in which students are presented with a scenario that involves an ethical dilemma. The scenario comes with several possible responses and the student/player is challenged with rank-ordering them in popularity. This requires that survey data regarding possible responses be available.

This work-in-progress paper discusses the outcomes from an Engineering Clinic project in which a multi-disciplinary student team produced 24 new scenarios. The goal of the project was to greatly expand the range of scenario options available to the instructor and ensure that the bank of available scenarios was suitable for a range of engineering courses. Before these new scenarios can be used in the game as designed, the survey data must also be collected. Data collection is ongoing at the time of writing and results will be included in the conference presentation.

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