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Piloting an Ethics Choose-Your-Own Adventure Activity in Early Engineering Education

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WIP: Piloting an Ethics Choose-Your-Own Adventure Activity in Early Engineering Education

Abstract

Engineering requires designing, redesigning, and developing new technologies that can have large positive impacts on society. But engineering can also come with negative, often unforeseen, consequences, side effects, or by-products. Dynamite, combustion engines, and opioids are a few examples of these positive contributions that later have had significant negative impacts. Understanding, evaluating, and mitigating those negative consequences is a large part of all engineers' duty to society. This requires students have an understanding of the ethical and societal impacts of their engineering choices.

In this work, we present an interactive, team-based, choose-your-own adventure activity that gives students the opportunity to practice the process of ethical decision-making based on an engineering scenario that has unforeseen negative impacts. Students navigate through the negative consequences of not only their personal decisions, but the decisions made by theoretical peers, management, and customers. Our aims for this project are two-fold: 1) to help undergraduate students see that engineering decisions made during the design, production, or even after launch of a product can have larger consequences than originally anticipated; 2) to determine if hands-on ethical problem-solving activities in the classroom increases student capability in ethical decision making.

We have introduced this choose-your-own adventure activity in two courses: the college-wide first-year Introduction to Engineering Problem Solving course and the second-year chemical engineering Process Calculations course. This work-in-progress will present initial feedback from students who have participated in the activity and an assessment of student ethical decision-making ability based on the Engineering Science and Issues Test (ESIT), comparing students that participated in the hands-on activities to those that received instruction only via lecture.

Introduction

As a profession, engineering has recognized the importance of ethical decision making and the need to train engineers to fulfill their duties in an ethical way. Engineering professional societies have adopted codes of ethics to help guide the professional conduct of their members. Further, with the 2019 accreditation cycle, the Accreditation Board for Engineering and Technology (ABET) elevated ethics to an independent student outcome, requiring all accredited programs in the U.S. to assess a student's "ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts" [1].

Discussion of case studies is a widely adopted approach to put students in decision-making roles that resemble those faced in school, on the job, or in society at large. There is a belief that "students that are exposed to paradigm engineering ethics case studies more capably understand and resolve similar real-life ethical issues and dilemmas to which they might be exposed on the job" [2]. However, the implementation of this approach often reduces the inherent complexity of

a real case to one of a single individual choice. This can make students think that ethical decisions are simple, obvious decisions that only occur in rare circumstances [3]. Traditional case studies rarely include multiple decision points where the first decision results in a next step with further ethical decisions to be made. Case studies are beginning to evolve with multi-branched interactive simulations that address many of these limitations [3]. One issue that is not typically addressed with traditional case studies and interactive ethics simulations is the impact of external influences, power and coercion, and cultural and organizational norms and values on decision making [4]. Without these influences, it is difficult to teach students behavioral ethics, which addresses why even people with the best intentions can make poor ethical choices [5]. Furthermore, neither case studies nor multibranch simulations give the students a chance to react when those influences counter their ethical decisions.

In this work, we present an interactive, team-based, choose-your-own adventure activity that gives students the opportunity to practice the process of ethical decision-making based on an engineering design flaw that impacts a product after it is sold. Our aims for this project were three-fold: 1) to help undergraduate students see that engineering decisions made during the design, production, or even after launch of a product can have larger consequences than originally anticipated; 2) to give undergraduate students a chance to adjust their actions/decisions and react to unexpected external influences; and 3) to determine if hands-on ethical problem solving activities in the classroom increase student achievement / development / understanding in ethical decision making.

Interactive Ethical Scenarios Studies

An interactive, choose-your-path ethics game was developed to provide student teams with an interactive, fun, and memorable experience with an ethical case study. Two ethical scenarios were developed for this game, with the following objectives guiding their development:

1. The scenario should be based on a real-life engineering case that is not easily identifiable by students.
2. The scenario should be written and completed in a way that engages students.
3. The scenario should involve multiple decisions throughout the case, and the subsequent chain of events should be shaped partly by the team's decisions and partly by external influences.
4. The scenario should include decisions that do not have an obvious solution but fall under multiple aspects of NSPE code of ethics, and should require students to weigh different ethical and professional responsibilities.
5. The scenario should result in multiple outcomes with the potential for substantial losses to the participants and external entities, such as human life, company solvency, job, credibility, and financial losses.

Objective 1: The scenario should be based on a real-life engineering case that is not easily identifiable by students.

It was important to base the scenarios on a real-life incident so students at the end can appreciate how the decisions they made could easily happen in the "real world". This gives an additional advantage of exploring the history of a case study where poor ethical decision making resulted in

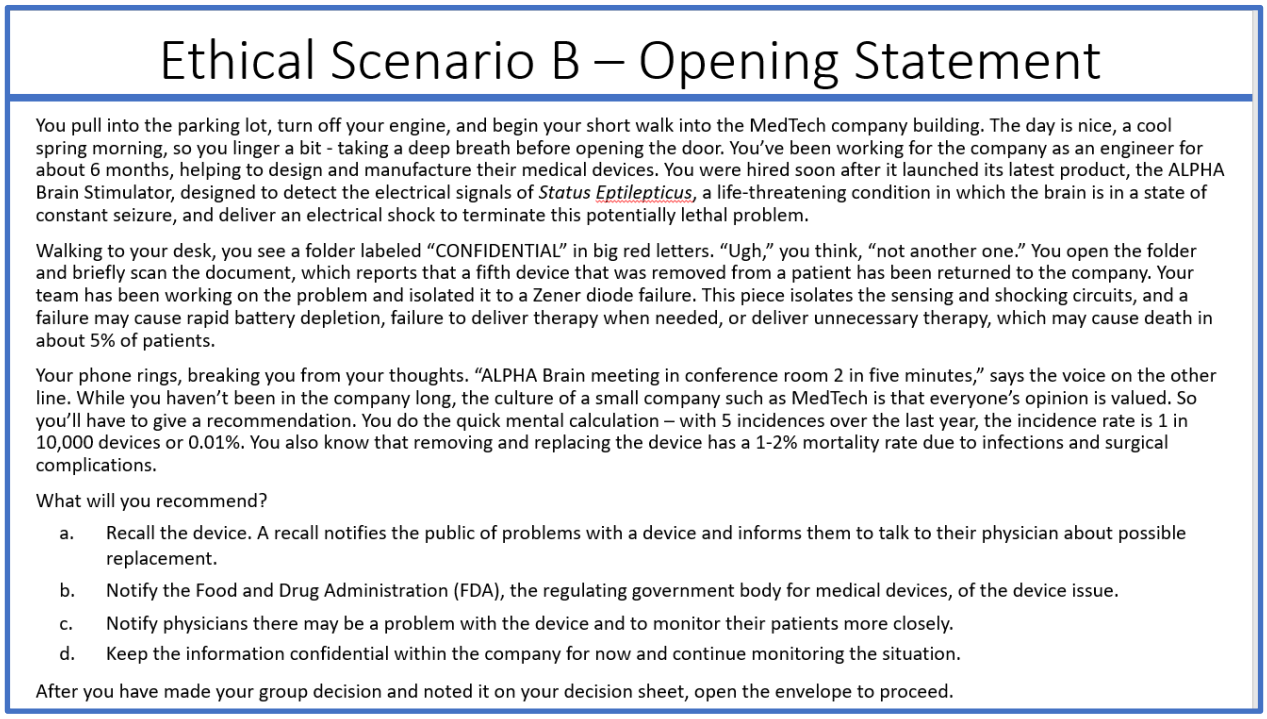
large negative consequences. However, it was also important that the students could not easily identify the scenario at the beginning, as this could bias the outcomes, causing students to shift their decision to one based on the historical context of the case rather than their own moral reasoning. This was achieved by either masking the original case by altering the nature of the fault, and/or choosing a base case that occurred long enough ago that it was not in the recent news cycle.

The first scenario (Scenario A) was based on the GM automotive ignition switch scandal [6, 7]. In 2004, GM engineers received reports of faulty ignition-switch failures that cause the vehicle to switch from run mode to accessory mode during operation with minimal pressure (such as a key chain, a large bump on the road, or hitting the key with your knee). This caused the power to be cut immediately to the engine, power steering, and safety features such as airbags. The failure resulted from a part in ignition switch being less than 2 mm short, not meeting specification, but still being approved for release. In 2005, the engineers did not deem this a large enough issue to start a recall, and instead a service bulletin was sent out in 2005 to advise customers "to remove heavy items from their key rings." A 16-year-old was the first reported death attributed to this fault. A GM engineer who initially approved the part then redesigned the part and implemented the new part without changing the part number in 2007. Several investigations occurred over the next years, but investigators struggled to find a correlation between the part and the crashes. Finally, in 2013 GM linked to the ignition switch to the crashes and blamed the fault in the ignition switch for 31 crashes and 13 deaths. In 2014, GM's CEO issued a recall on 2.6 million vehicles, costing the company about $1.25B. It was determined that GM delayed reporting the issue and the company was required to set up a $594.5M settlement fund. In all, 124 death claims were attributed to this issue. Throughout this incident, many poor ethical choices were made which exacerbated the loss of life, money, and reputation.

The biomedical device case (Scenario B) was an expanded version of one written by Lewis et al. involving a diode failure in a brain stimulator used to prevent epileptic seizures [8]. This scenario is based on the real-world case involving Medtronic's Marquis™ and Guidant's Ventak™ implantable defibrillator device recalls in 2005. These two recalls were interesting because they involved two manufacturers with similar device failures in similar products and with the same customer base. But the two manufacturers chose very different courses of actions. On February 10, 2005, Medtronic provided notice that certain cardiac defibrillators manufactured between April 2001 and December 2003 had a potential battery shorting problem which could result in rapid battery depletion. If the battery in a defibrillator shorts out, the device will not function, i.e., it becomes unable to deliver the therapy required when a user develops potentially life-threatening arrhythmias. Since the batteries are located within the implanted defibrillator, the device needs to be surgically removed to eliminate the defect. Guidant, on the other hand, began its recall in May 2005 after a 21-year-old patient died of sudden cardiac arrest that March. The implantable Guidant defibrillators were recalled because of a faulty capacitor which could cause the batteries to deplete sooner than expected. The company knew about the problem for three years and had been reporting to the FDA but did not alert physicians. Guidant was aware of 25 other cases in which the defibrillator was affected by the same flaw. This issue caused the FDA to subsequently review and change their medical device filing process.

Objective 2: The scenario should be written and completed in a way that engages students.

Each case was written in the viewpoint of a gender-neutral early career engineer. While the cases are based on technical flaws, the scenarios are written with enough background that first year college students will be able to understand the basis for each decision. Students were able to read the decision points and easily imagine themselves in the scenario (see Fig. 1 for a sample opening statement). The students then become the person making the decisions and cannot duck or skirt around an issue, but must face the problems head on [9].



Ethical Scenario B – Opening Statement

You pull into the parking lot, turn off your engine, and begin your short walk into the MedTech company building. The day is nice, a cool spring morning, so you linger a bit - taking a deep breath before opening the door. You've been working for the company as an engineer for about 6 months, helping to design and manufacture their medical devices. You were hired soon after it launched its latest product, the ALPHA Brain Stimulator, designed to detect the electrical signals of *Status Eptilepticus*, a life-threatening condition in which the brain is in a state of constant seizure, and deliver an electrical shock to terminate this potentially lethal problem.

Walking to your desk, you see a folder labeled "CONFIDENTIAL" in big red letters. "Ugh," you think, "not another one." You open the folder and briefly scan the document, which reports that a fifth device that was removed from a patient has been returned to the company. Your team has been working on the problem and isolated it to a Zener diode failure. This piece isolates the sensing and shocking circuits, and a failure may cause rapid battery depletion, failure to deliver therapy when needed, or deliver unnecessary therapy, which may cause death in about 5% of patients.

Your phone rings, breaking you from your thoughts. "ALPHA Brain meeting in conference room 2 in five minutes," says the voice on the other line. While you haven't been in the company long, the culture of a small company such as MedTech is that everyone's opinion is valued. So you'll have to give a recommendation. You do the quick mental calculation – with 5 incidences over the last year, the incidence rate is 1 in 10,000 devices or 0.01%. You also know that removing and replacing the device has a 1-2% mortality rate due to infections and surgical complications.

What will you recommend?

a. Recall the device. A recall notifies the public of problems with a device and informs them to talk to their physician about possible replacement.
b. Notify the Food and Drug Administration (FDA), the regulating government body for medical devices, of the device issue.
c. Notify physicians there may be a problem with the device and to monitor their patients more closely.
d. Keep the information confidential within the company for now and continue monitoring the situation.

After you have made your group decision and noted it on your decision sheet, open the envelope to proceed.

Figure 1. Opening statement for Scenario B, the biomedical device failure case.

Since there are multiple decision points, the students can become more involved and invested in their outcomes with each decision. Each case becomes more detailed as it plays out, such as including the full name of someone who died in each of the original scenarios (Fig. 2). As personalized cases are more effective at developing critical thinking skills and remembering factual information [9], this allows the students to make the connection that their decisions throughout their careers will affect real people and not faceless numbers.

Students worked in teams of 4-6, first recording their own decisions and thoughts on which path to take before discussing and coming to an agreement as a team. With larger teams it was less likely that every team member would choose the same next step. Therefore, the students had to think and articulate the reasoning behind their choice and not go with a "gut feeling". Students also had to engage with each other and could not just quickly choose and move on without additional input/thought.

To further enhance the student engagement throughout the scenario, each decision point was printed on a separate card and placed in different labeled folders throughout the room. This

forced the students to physically move throughout the classroom. We chose this mode of interaction since "educational activities occurring simultaneously with physical movement have been shown in numerous studies to likely influence academic achievement" [10].

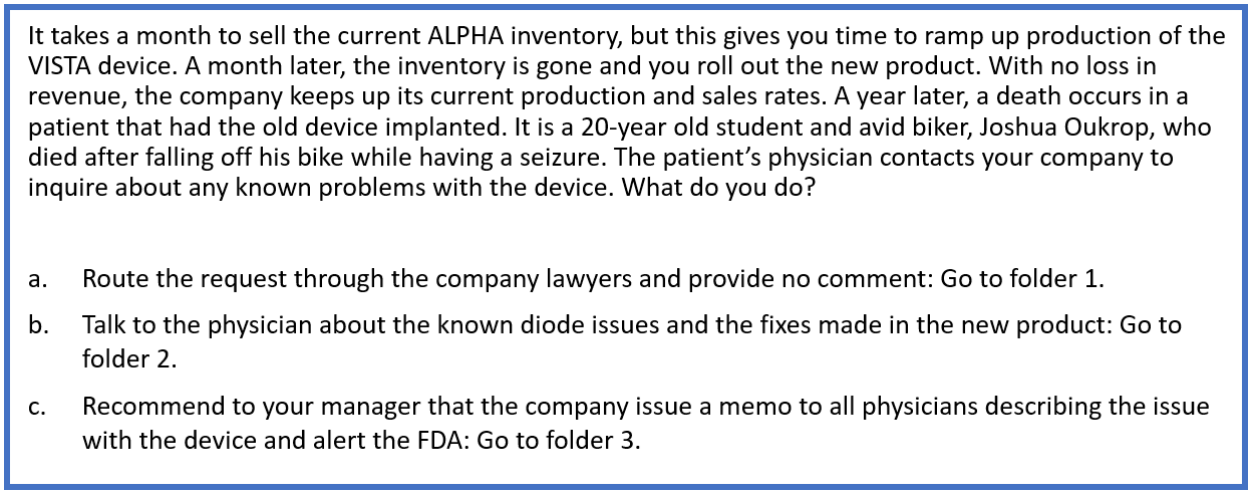


Figure 2. Sample decision point showing how scenarios become more detailed with facts from the cases on which the scenarios were based. Note that each decision leads students to a different folder, and therefore down a different path.

Objective 2: The scenario should involve multiple decisions throughout the case, and the subsequent chain of events should be shaped partly by the team's decisions and partly by external influences.

Each scenario was design for the student groups to resolve four to nine decisions points (~30 minutes of playing time) creating multiple pathways and outcomes. Each decision points lead to a new page/folder where the story continued to unfold (Fig. 3). This created a complex ethical situation where several smaller, sometimes seemingly inconsequential decisions could have much larger effects. Students may initially believe that only bad people get stuck in bad situations. This narrow view does not consider how the behavioral ethics of each student and others in their team interact. By exploring a more complex situation with multiple choices, social and psychological factors (e.g. incrementalism, conformity bias, loss aversion) can be explored. These factors greatly influence a person's judgement but are not widely taught in the context of engineering education [4]. This approach is similar to multi-branched interactive ethics simulation developed by Beal and Orbison [3].

The ethics game differs from the Beal and Orbison's set-up by including external or outside forces that influence the team's pathway, causing them to have to react in less-than-ideal circumstances. The external sources included possibilities such as a manager either agreeing with or overriding your decision, a supply chain shipment coming either early or late, or a colleague going public with damaging knowledge to the company or that colleague keeping it internal. Each of the external sources was represented by a game of chance (Fig. 4).

The games of chance included flipping a large coin, rolling a huge die, spinning a game wheel, drawing an oversized card, or picking a marble from a bag. Each of these games represented

different odds that the company or company employee would continue with the team's choice of path. This was another interactive piece for the students to engage in physical movement, as well as having them react to unforeseen circumstances. The games of chance also allowed a short brain break to help re-engage students with the material and limit decision/discussion fatigue [11].

The test is repeated with the same results as before. You investigate further and see that the ignition switch turn the car from run to accessory mode meaning power to the engine/power steering/brakes/safety devices (such as airbags) is immediately cut out if the key chain is too heavy and/or jostle just right. The senior engineer noted this as unlikely but planned to send a safety memo out to all car dealerships to prevent people from having big heavy key rings. At this point it will cost $0.90 / per car ($400,000 fix) to install safe redesigned ignition switches and delay to the launch a year. You must recommend a plan of action to your manager, what do you recommend? Write down your answer and go to folder 4.

a. Go with original plan of sending out a memo to stop the problem but keep everything on schedule and budget.
b. Send out the memo but change the part for the next lot, keeping you on schedule but not on budget ($200,000 fix).
c. Stop production to get it fixed immediately costing $400,000 and delaying the launch.
d. Use the whistle-blower policy to directly contact the CEO without informing you manager.

Figure 3. Sample decision point in the automotive failure scenario where financial costs and time must be weighed against safety to consumers.

You give your recommendations and support to you manager. The manager will take care of it and puts you on another job. Please spin the wheel (representing random chance and the manager's actions) to see what happens next.

a. If you spin green: The manager sends out the memo but does not instigate the change. Go to folder 5.
b. If you spin yellow: The manager sends out the memo and instigates the change. Go to folder 6.
c. If you spin red: The manager delays production. Go to folder 7.
d. If you spin blue: The manager goes with your recommendation. Go to the appropriate folder from above.
e. If you contacted the CEO. Go to folder 8.

Figure 4. Continuation of decision from Figure 3 where outside influences are modeled through a game of chance.

The deeper purpose of external influences was to force the students to react in situations they may not realize are possible (given that they may make an ethical choice). The linear thought process with traditional case studies, and even the multi-branch simulation, re-enforces the linear concept of fairness, i.e. the "right" decision always proves to give a positive outcome. Outside influences are rarely considered in the teaching of ethics, though they are prevalent through life. Including outside influences through games of chance pushed students to further explore how to

react ethically even when others may not, an aspect that may become a vital skill in their future careers.

Objective 4: The scenario should include decisions that do not have an obvious solution, but fall under multiple aspects of NSPE code of ethics, and should require students to weigh different ethical and professional responsibilities.

Students often needs guidance and experience to judge ethical situations, and having a professional code like the NSPE can provide a baseline of moral norms accepted by a profession [12]. The ethical game was taught in conjunction with the NSPE code of ethics, so it was important to incorporate several decisions where the students could use the NSPE code as guidance. For example, the NSPE third fundamental cannon states that you should "Issue public statements only in an objective and truthful manner." [13] However, as shown in Fig. 5, this issue can be complicated by competing priorities, particularly when it competes with the fourth NSPE fundamental cannon "Act for each employer or client as faithful agents or trustees." The code can act as a guide by giving students knowledge, support, and confidence to make the ethical choice even if they do not fully understand the implications of their work. In this particular example, "deflecting the blame onto the supplier" causes the supplier to cut ties with the company (delay production) and to sue the company for libel. These may be unforeseen circumstances to students with limited experience, but avoidable by following the professionalism code in order of importance based on the numbering of the canons.

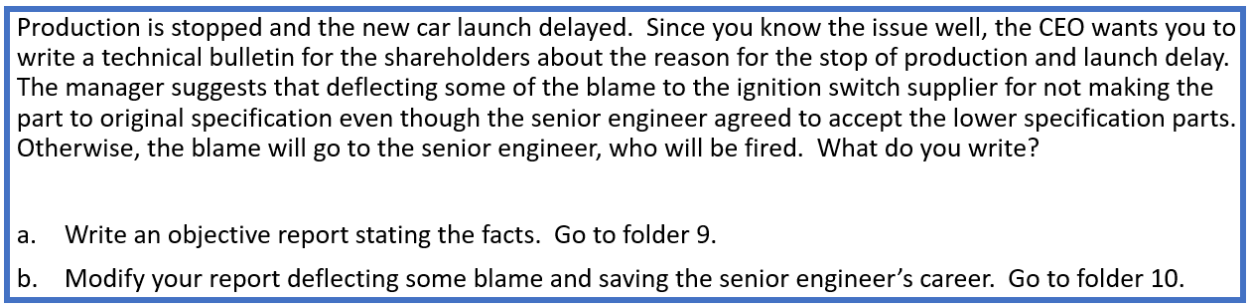


Figure 5. Decision point where following the NSPE code of ethics can directly be applied.

Objective 5: The scenario results in multiple outcomes with the potential for substantial losses to the players and external entities, such as human life, company solvency, job, credibility, and financial losses.

All paths were chosen to conclude in a realistic possible endpoint based on the decisions made. In Scenario A (automotive case), there are 210 distinct pathways that lead to 15 different endpoints. In Scenario B (biomedical case), there are 271 distinct pathways that lead to 24 different endpoints. Each endpoint included facts about the probable effects on a participant's career, the company, finances, and society (Fig. 6 and 7 show a positive and negative outcome, respectively). Furthermore, an overview of the original case study that the scenarios were based on was provided to the students so they could compare their outcomes to those of the actual case.

You continue to work with the supplier and lead the project. Through your hard work and luck, the supplier manages to get the redesigned ignition switches to you ahead of schedule. Instead of a year delay, the stop of production only lasts 3 months. Overall, the budget overages only costed ~$400,000 which is exceptionally good with this type of major issue. Your reputation as both an engineer and a good project leader grows. You soon get promoted to bigger projects and have a great career.

This is a possible outcome of the GM ignition switch scandal if the engineers had acted more ethically. To read what really happened in this case go to folder 11 and take a copy of the case summary and the reflection questions assignment.

Figure 6. A positive outcome sample endpoint from Scenario A.

The National Highway Traffic Safety Administration (NHTSA) quickly realizes there is a correlation between the crash and the redesigned switch. The faulty ignition switch is to blame for at least 20 crashes and 10 deaths. GM is force to issue a recall on 2.0 million cars. GM has to pay a $35 million dollar civil penalty and $1.0 billion in recall related expenses. The CEO put all the blame on you, your manager and the senior engineer. You are fired from GM and must testify before congress about your role. Your reputation in the field is destroy since you did not follow the engineering code of ethics. You cannot find another job in this field.

This could have been an outcome of the GM ignition switch scandal. You made the similar decisions as the engineers in the case. To read what really happened in this case go to folder 11 and take a copy of the case summary and the reflection questions assignment.

Figure 7. A sample endpoint with a negative outcome from Scenario A.

Student Performance and Assessment

The game was implemented in the fall semester of 2019 in 6 of 13 discussion sections in the first-year engineering design course (IEPS) required of all undergraduate students in the College of Engineering and in the materials and energy balance course for second-year students in the Department of Chemical and Biochemical Engineering. Out of 476 students enrolled in the two classes, 218 students participated in the interactive case study. As a pre-assessment in moral reasoning, at the beginning of the semester all students were asked to complete a survey comprised of four of the six cases from the Engineering and Science Issues Test (ESIT, described below). Prior to the interactive case study, several lectures and activities introduced first-year students to ethical decision making in engineering. In the discussion sections that implemented the interactive case study, one class was devoted to students creating their own code of ethics, then matching their codes to the NSPE Code and generating a list of additional codes that are not in the NSPE Code. Next, a lecture introduced all first-year students to the NSPE Code of Ethics and had students play a virtual game in which they chose a building(s) to flood (for example, school versus manufacturing plant, government building versus local housing community) as a way to practice weighing multiple factors. The second-year students were given a lecture on behavioral ethics after they played the simulation. However, the students would have had a lecture in the IEPS course the year before. After these lectures and activities, students played the interactive game in teams of four to six, which generally took about 30 min for each team to complete. Upon completion of the game, students completed a questionnaire about their decision points, game play, and how the case related to the NSPE Code of Ethics. During the following class, the faculty facilitators led a discussion of the case with the students.

At the end of the semester, all students were again asked to complete a survey with four of the six cases from the ESIT.

The Engineering and Science Issues Test (ESIT) was developed to assess ethics pedagogy in science and engineering [14]. Its design was based on a widely used and validated instrument for assessing moral judgment, the Defining Issues Test (DIT-2) [15]. DIT test scores have been linked to desired professional decision making and are sensitive to moral education interventions. Both the DIT and ESIT tests use one-paragraph case studies to present ethical dilemmas, then require the participant to rate and rank twelve issues that could be important in making a decision. The issues activate and are used to assess a participant's preferred moral reasoning schema, either preconventional, conventional, and postconventional schema. These schemas are characterized by either a narrow personal interest, an appeal to duty and maintenance of the existing social norms, or the search for moral ideals on which a social order ideally ought to be based, respectively. The tests are scored to determine which schemas the participant brings to the task. Two main scores are calculated to reveal the degree of post-conventional reasoning (P-score) and the preference for postconventional reasoning and rejection of preconventional reasoning (N2-score). Several nonsense answers are placed throughout the test to identify subjects who are not taking the test seriously. In our analysis, we used DIT-2 scoring equations to determine P-scores, as shown in (1), and N2-scores, as shown in (2) [15, 16].

$$\text{P-score} = (4 \times \#\text{ of post-conventional issues ranked first} + 3\times \#\text{ post-conv second} + 2 \times \#\text{ post-conv third} + 1 \times \#\text{ post-conv fourth}) / (60 - 4 \times \#\text{ first ranking omitted} - 3\times \#\text{ second rankings omitted} - 2 \times \#\text{ third ranking omitted} - 1 \times \#\text{ fourth rankings omitted}) \times 100 \quad (1)$$

The P-score accounts for how many post-conventional issues were ranked as the most important considerations and is weighted by the maximum number of points possible. Missing data is dealt with by adjusting the P-score to subtract the number of issues that were omitted by a participant. The P-score ranges from 0 to 98, with a higher score showing a more advanced post conventional ethical understanding.

$$\text{N2-score} = \text{P-score} - [3 \times (\text{average rating on preconventional issues} - \text{average rating on postconventional issues}) / \text{standard deviation of pre- and postconventional issues}] \quad (2)$$

The N2-score equation uses the responses to the first ranking task (i.e., rate importance of all 12 questions), with the most important given 4 points down to no importance given 0 points. The factor of 3 is used to weight the second component because the component has about one-third the standard deviation of the P-scores [16]. The N2-score has a maximum score of 110 with the higher score reflecting the participants prefer to base their reasoning on the post-conventional schema over the pre-conventional schema [17].

In accordance with Institutional Review Board (IRB) policies, students were able to complete or decline all surveys without consequence. Consent to take part in the study was provided by 202 students (48%). The ESIT survey has rules of exclusion provided in the article by Borenstein et al., such as insufficient data filled out, improper data filled out, or too many nonsense scores.

The surveys of sixty-one students who consented (30%) were omitted from analysis. Most of the omitted surveys were students incorrectly filling out the survey, by giving multiple selections in ranking the most important question. Only two surveys were eliminated based on nonsense scores.

Open-ended reflection questions asked after completion of the interactive game included:

- *Were there any points where you disagreed with your team and why did you eventually agree to the team's choice?*
- *Which decision was the hardest to make? Why?*
- *How did you feel relying on chance (other people's influence) to affect your outcome?*
- *Do you feel your case outcome was positive? Why or why not?*
- *Knowing how your scenario played out, would you have changed any of your choices?*
- *How did this game contribute to or change your understanding of ethics?*

Reflections from Classroom Observations and Student Surveys

Several observations were made by the faculty and teaching assistants during the interactive choose-your-own-path ethical game. First, student engagement in the activity was high, especially as teams moved from point to point, and instances of animated discussions were observed in every class. Students appeared to be enjoying themselves and were excited to get to the "games of chance", though their feelings about this changed once they understood the potential ramifications on their final outcome (more discussion below on this). It was important to have multiple people (faculty, teaching assistants) in the room monitoring the process so that participants could not go back and choose a different path when they realized they didn't like the path they were on or when a game of chance didn't go the way they hoped. At some point during game play, student groups would realize that the scenario was based on a "real" case and would begin to ask questions about it. At one point we overheard the surprised comment from one student, "She had a middle name!" Therefore, providing information at the end of the game about the actual cases was important. Finally, while the groups shared some information about their path and outcomes during the debriefing discussion, the overall decision trees were not shared with the students, leaving this a mystery. This seemed to be a positive aspect because it enticed students to discuss the case with each other. In fact, sometimes the game and results got stuck in the students' heads and the authors would be asked questions or hear students talking about their results weeks after the game was over.

A qualitative analysis of comments from the ethical game reflections that each student completed after playing the choose-your-own-path ethics game was conducted. Surveys from 148 students (out of 218 students that played) were collected; two sections did not provide data from their student cohorts.

When asked '*Do you feel your team made ethical choices throughout?*', 92% of first-year students and 85% of second-year students answered yes. Many students commented on the conflict presented when considering the safety of the public versus company interests and loyalty. Some of the answers to this question included:

- "I think we made ethical choices for the most part. We could have used the whistle blower maybe one turn before."
- "I feel my team chose the best options and I agreed with all of them."
- "I feel that we tried really hard to make the right decision without going directly to the CEO at every sign of trouble."
- "I feel we always did what was best for the public while keeping our company in mind."
- "Yes, we agreed on most topics. We picked the choices that saved the most lives."
- "We tried, but still caused hundreds of millions of dollars in damage and hundreds of deaths."
- "No, sometimes other things took precedence over it."
- "For our 2nd decision point, I was really struggling whether to pick B or C. I felt that trying to save money and time was important, but ultimately safety and reputation of the company is really important."

When asked '*Knowing how your scenario played out, would you have changed any of your choices?',* 33% of first-year students and 40% of second-year students said yes, they would have changed a decision. Which decision the students would have changed varied greatly between the two case studies because of how their case played out based on both their own decisions and outside influences, and based on whether their team went along with their own personal decisions.

Throughout the game, students were instructed to make their own decision before discussing it as a group and coming up with a group decision. Sometimes students had to grapple with whether to defend their choice or go along with the group if they had made a different choice. In the surveys, the students discussed making group decisions generally in one of three modes: by each discussing their thinking process and coming to a joint agreement because they were already in close alignment, by one teammate making a good argument and convincing others to change their mind, or by the groups taking a vote and having the majority make the decision. Only one student noted that decisions needed to be made, so they just went along with the group.

Most of the students were uncomfortable with having outside influences overrule their decisions. Common answers to the question '*How did you feel relying on chance (other people's influence) to affect your outcome?'* were nervous, uneasy, frustrating, worried, helpless, unempowering, and like we had no control over the situation. A few students commented that relying on other people's influence made the game more realistic or noted that while they didn't like it, that's life. These thoughts were echoed in and expanded on in answers to the question '*How did this game contribute to or change your understanding of ethics*?':

- "No matter how ethically I act, some unethical outcomes are out of my control."
- "Some things are out of our control, but we can still make a difference."
- "Even if you make ethical choices, not everyone else will. To not be afraid to be the whistle-blower if people's lives are at stake."
- "It helped me understand how chance and other people can play huge roles in what happens in engineering."
- "I realized that big ethical decisions won't always me made to my liking."
- "It changed how I see decisions be made. You would think it would be all together but we had to convince each other about our decisions."

- “Understanding that other people could affect your career.”

This last question further provided a rich variety of thoughts from students about the ethics game and ethical decision making in general. Common themes expressed based on this question centered on the importance of the first NSPE cannon “holding paramount the safety health, and well-being of the public”; how important each decision, particularly early decisions, were in determining the outcome; how ethics translates into real life; how hard these choices can be; and how much damage can be caused by one decision.

- “Makes me see how hard it is to uphold the canons because of other factors.”
- “It actually applied a real world situation to the canons that we have been learning, its interesting how things played out with GM.”
- “It helped me understand how hard ethics dilemmas are at times.”
- “It shows that doing the correct thing can hurt at first but is good in the long-run.”
- “There will most likely always be a downside to your decisions, as something must be sacrificed for the common good.”
- “It helped me understand why they are important in the design process.”
- “Ethics can be messy. Some scenarios are not black and white.”
- “It showed how hard it can be to make ethical decisions in real life.”
- “It made it feel real.”
- “It helped me understand better our role in ethics decisions.”
- “It made me realize how much of an effect ethics has on engineers.”
- “These issues happen in all companies and your decisions can have a high impact.”
- “Before the game I didn’t understand how much of an impact our small decisions would have on the eventual outcome of the case.”
- “It makes you realize the weight each decision can have.”
- “There are so many choices to make, all with separate consequences that have a real impact.”
- “There’s a lot more to it than losing money and that the reputation and public safety plays a huge role.”
- “It made it more obvious how unclear ethical situations can be.”

Seven percent of students said that the game did nothing to change their understanding.

Results from ESIT Test

After reading each ESIT scenario, participants were asked to decide how the engineer in the case study should respond. Responses from both the pre- and post-tests generally matched the reported responses of students at a small Midwestern university [18]. Students generally agreed on their responses to two of the cases (Leak and Testing), with about 90% choosing the same response (Fig. 8). Responses to the other three cases (Contract, Product, and Technology) were more diverse and included a larger number of undecided responses. In the post-test, the initial Contract test case was replaced with a more diverse Technology test case, which may have resulted in some difference in the student P- and N2-scores.

One goal of this study was to determine if the ethical intervention of playing the choose-your-own-path game impacted student moral reasoning. The control group in this study did not play the interactive game but did get several lectures on ethics. The experimental group includes the pooled responses of both the first year and second year students who played the game. The ESIT results of the P- and N2-scores are provided in Table 1.

A two sample Welch's T-Test with unequal variance was run between the control and experimental pre-test and showed the P-Score average of the control's population is equal to the average of the experimental population before the simulation ethical intervention with a p-value of 0.909. A two sample Welch's t-test between the control and experimental N2-scores on the pre-test showed similar results with a p-value of 0.840. Therefore, both the control and experimental groups have the same ethical starting point within 95% confidence.

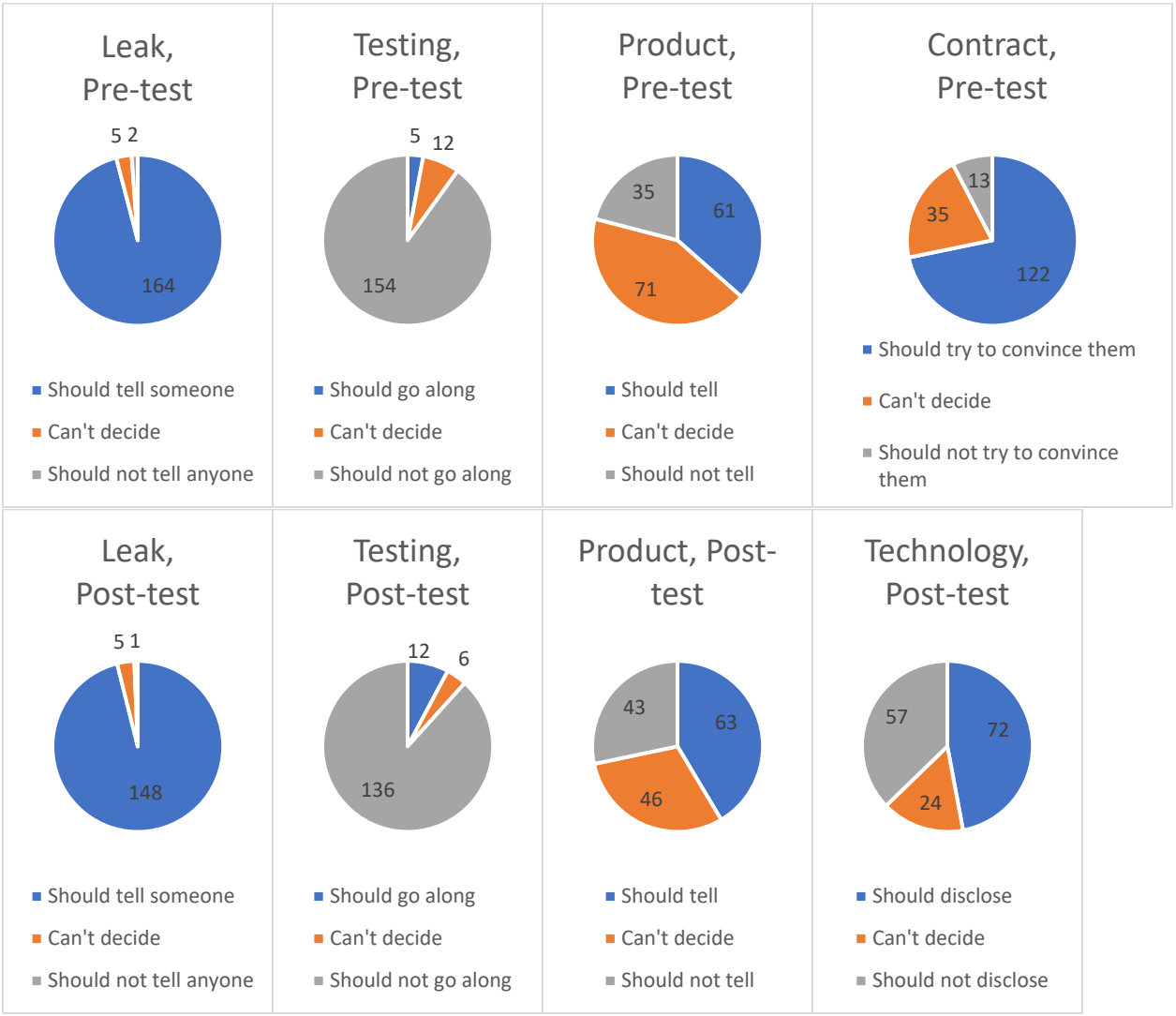


Figure 8. General response breakdown for each ESIT scenario in the pre-test (before intervention) and post-test (after intervention) surveys.

Both the control and the experimental groups showed a slight drop in both the P-score and N2-

score indicating a reduction in post-conventional reasoning. In our analysis, it became clear that this was due the change in the initial Contract test case to the more diverse Technology test case. In addition, there was the reduction in the number of scenarios from the six which are in the full ESIT test to the four which we used to reduce the time of the survey. In our future work, all six scenarios will be included in the ESIT test to resolve this difference.

While both P-scores and N2-scores dropped due to the change in test cases, the level of drop was lower for the experimental group. The average difference from pre- to post- ESIT P-scores was not statistically significant. However, the difference in the pre-test and post-test scores between the control and experimental groups was statistically different (p-value of 0.0001). This may indicate that the addition of the choose-your-own-path game did have a positive effect on the student's preference for postconventional reasoning and rejection of preconventional reasoning for both groups. However, more testing must be performed to confirm this.

Table 1. General response breakdown for each ESIT scenario in the pre-test (before intervention) and post-test (after intervention) surveys. Control group = students that did not play the game. Experimental group = students that played the choose-your-own-path ethics game.

		Control		Experimental	
		Pre-Test	Post-Test	Pre-Test	Post-Test
	Number	83	83	58	58
P-score	Average	59.066	54.398	58.793	56.638
	Standard Deviation	14.460	13.890	13.671	14.649
	Average Difference	-4.669		-2.155	
	T-test on difference	p-value = 0.29155			
N2-score	Average	61.511	57.222	61.000	58.866
	Standard Deviation	15.148	14.421	14.556	14.614
	Average Difference	-4.289		-2.134	
	T-test on difference	p-value = 0.00010			

Future Developments

The interactive choose-your-own-path ethics game engaged undergraduate students with ethical decision making that had consequences larger than originally anticipated and that were affected by external influences. We plan to adopt several modifications and to include additional student cohorts to increase the number of participants in future iterations of the game.

The simulation will continue to be implemented in both courses already described. We will be training faculty that run additional discussion sections of the first-year engineering design course, which will quickly expand game use. A complete course drop-in package will be developed for faculty to easily employ in their classes. The ESIT will again be administer at the beginning and end of the semester, but we will revise the ESIT survey to include all six cases, instead of only four as used in this work-in-progress study. The larger number of cases and the

additional sections of students completing the choose-your-adventure game will provide significantly more data points for analysis. To help facilitate analysis of the data, scantron or an online version of the ESIT will be investigated.

Further, the simulation will be used throughout other chemical engineering courses to expand the ethics instruction in the department. The authors are also exploring how multi-year use of the simulation may increase student's ethical decision making over longer periods of time (years instead of a semester). A final ESIT (including all 6 cases) will be administered when the students are seniors to compare to those of the second year.

Additional case studies will be developed so students can engage with different cases throughout their time in the program and learn new aspects of the NSPE code. The current cases primarily reflect the fields of mechanical / industrial engineering (automotive case study) and biomedical engineering (brain stimulator case study), even though they are written so all engineers can understand them. The authors plan on introducing several more cases that reflect a variety of fields and additional ethical dilemmas, to show that ethics affect all aspects of engineering.

Finally, a recommendation was provided by our advisory board when they played the choose-your-own-path game, which we plan to implement: to add a consulting desk in the room so that participants have an obvious place to go with questions (e.g., what does a recall to the FDA mean or what is a whistle-blower policy?).

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