An Interactive Professional Ethics Case Simulation

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Abstract

At many universities, engineering ethics education relies on case studies to instruct students in the process of identifying ethical dilemmas, generating potential solutions and selecting the best option. This paper describes an approach to engineering ethics that takes advantage of the Internet to deploy the case study method with an interactive approach intended to increase the realism of the experience and enhance student engagement. Data are presented from voluntary student surveys completed prior to and after completion of the activity. Results suggest that the interactive approach is at least as effective as a traditional case study and provides an individualized experience, even in a large-class setting.

Introduction

Case studies are a preferred vehicle for professional ethics education and are used by both academic programs and professional societies. (Richards & Gorman, 2004) note that “Case studies often reflect real world concerns, situations, and issues managers and engineers encounter in practice; they are often open-ended, with no clear-cut solution.” And according to (Herkert, 2000), they “encourage students to express ethical opinions, identify ethical issues, and formulate and effectively justify decisions.”

There are disadvantages, however, that limit their educational effectiveness. At the conclusion of the case, the appropriate course of action may be obvious, particularly with well-known cases. Students may view the events described in the case as exceedingly rare occurrences that they are unlikely to encounter in their careers, or they may not consider the employment scenario presented as a realistic possibility for themselves. A third-person account of events also may not provide the experience required for students to engage emotionally, as is suggested by (Newberry, 2004). Further, cases rarely include multiple decision points in which one decision will result in the continuation of the ethical dilemma, or presents a different dilemma, that must then be addressed in one or more subsequent decision points. In many real-world scenarios, moral dilemmas are reached through a series of decisions with subtle but accumulating negative outcomes rather than a single choice between clearly ethical and unethical options. Not only are these accumulating outcomes more difficult for students to predict, but they may also experience “decision fatigue” as described by (Vohs et al., 2008) where their ability to make the most ethical decisions declines as they are faced with multiple decision points.
To address these limitations, a multi-branched, interactive ethics simulation has been developed. Delivered to the students via a web application, the activity requires students to alternate between reading a narrative segment of a case and choosing the best course of action in response at a series of decision points. Their choice of action leads to a choice-specific branch within the case, which includes multiple decision points that are encountered sequentially. Along with the narrative segments, the application also includes sidebars similar to those introduced in the work of (Jonassen et al., 2009) that present viewpoints of stakeholders, additional context associated with the decision, and relevant sections of the National Society of Professional Engineers’ (NSPE) Code of Ethics. While the delivery method through the Internet is similar to that introduced by (Haws, 2002) as well as (Chung & Alfred, 2009), the simulation presented here differs in that it simulates the varied possible storylines beginning with a single engineering problem. The simulation also tracks the students’ path through the simulation and provides feedback to them as to the impact of their decision on their score. The remainder of this paper describes the design objectives for the simulation, the implementation, and results obtained when deployed in a first-year general introductory engineering course. Aggregated data and responses to open-ended questions from a subset of students who completed pre- and post-simulation surveys are provided, with discussion of the outcomes of the simulation.

**Interactive Case Study**

An interactive ethics simulation has been developed to address several of the limitations inherent in the use of traditional case studies. The case is an expanded version of one written by (McFarland, 2012) involving a software development project in which a software error, or “bug,” is discovered shortly before the software is to be delivered to the customer. This case was chosen because it is engineering-related but does not require students to have any discipline-specific technical knowledge, making it suitable for use in a first-semester introductory engineering course.

The following objectives guided the development of the case:

- The case scenario should be realistic, i.e. students should be able to readily identify with the project, and consider the occurrence of the technical problem described in the case to be relatively common.

- The case should present the potential for a strongly negative outcome: one that involves loss of human life. At the same time, the probability of occurrence of that outcome should be uncertain, and relatively low.

- The case should require students to engage in decisions at multiple points throughout the case, and the subsequent chain of events should be shaped by those decisions. Many ethical dilemmas evolve from, and persist through, a chain of subsequent decisions. Furthermore, the case should elicit “decision fatigue,” which impairs decision-making abilities when individuals are required to make a series of decisions (Vohs et al., 2008).

- The case should present increasing risk, and personal costs, as each decision point is reached and completed.
The case should be written in the first person, to create a near role-playing environment to engage students (Hunger, 2013; Alpay, 2011). This enhancement of the emotional engagement of the students studying the case should yield increased retention, as described in (Newberry, 2004).

The case should be undertaken by teams of two or more students, thus requiring discussion and deliberation, and introducing peer pressure influence on their decisions.

Case implementation should directly impact the students’ course grades, and the case grade should reflect the quality of their decisions. Grade additions or penalties should be assigned at the completion of each decision, and reported to the students at that time. The web implementation should prevent students from changing their decisions once the grade increment has been reported.

Linkages to the NSPE Code of Ethics should be provided at multiple points within the case through the use of sidebars that accompany the narrative.

The primary actor in the case should be gender-neutral and have sufficient autonomy to make the decisions described in the case (Bagdasarov et al., 2013).

The case should include one or more scenarios in which the primary actor faces pressure from supervisory personnel to make, or accept, an unethical decision.

The case itself involves a fictitious commercial software development firm that has been retained by the Federal Aviation Administration (FAA) to develop a pilot version of the next generation of the air traffic control system to be employed at commercial U.S. airports. The project, with a two-year duration, includes the promise of a more substantial follow-on contract to scale up the system for widespread use in the U.S., provided the pilot system works well and is delivered on time. Internally, the company has promised a large cash bonus to the employees and manager working on the project if the software is delivered in advance of the FAA deadline. In the last week of the final testing phase, six days before the deadline to earn the bonuses, a transient “bug” appears, for the first time and only once, that results in the incorrect display of the flight altitude of multiple aircraft. The displayed flight altitudes return to their correct values a short time later without operator intervention. The bug does not recur in subsequent intensive and focused testing undertaken in that week before the bonus deadline.

The primary actor in the case is identified as a relatively senior software engineer whose team is responsible for the testing phase of the project and has worked on the project throughout its duration. The engineer is expected to certify that the software functions effectively as required and is safe for implementation by the FAA. The case study includes a discussion of the near-certainty that software of any significant complexity will contain bugs, and that they are typically repaired through software patches in subsequent updates.

The implementation requires students to read a narrative segment and sidebar information as seen in Figure 1. They then choose the best course of action from a list of possible decisions. Once the students select an answer and submit it, they are provided with feedback as to the immediate consequences of their decision, both in the simulated story as well as for their score for the activity, as seen in Figure 2. A subsequent narrative and sidebar, specific to their decision, is then displayed, along with another set of decisions.
There are 120 different paths through the case, with 15 different endpoints reflecting realistic outcomes based on the decisions made, as seen in Figure 3. Each path requires the student groups to make a minimum of four, and as many as nine, decisions in the simulation. Students begin the case study with a score of six points, reflective of an average ethical and professional reputation. Points are awarded or deducted at the completion of each decision point, and the point increments reflect a combination of the ethical strength of the decision and the personal cost. This is done very specifically to make the decisions reflect the real-world balance between doing the “right thing” and protecting an individual’s reputation, the company’s finances, or even co-workers’ jobs. While some decisions that might be considered to be strongly ethical result in mixed results due to the complication of personal impacts, the overall scores for the most transparent and ethical paths earn significantly more points than those that end with an unethical decision or even an ethical outcome reached by way of earlier questionable decisions.

End scores ranging from zero to 10 points are possible; only three of the 120 paths will result in a score of 10 points. As the software bug has the potential to cause a midair collision between commercial flights if implemented, a top score of 10 points requires the main actor (i.e. the student groups) to assume the role of whistleblower, directly communicating with the client (FAA) after attempting, and failing, to convince the actor’s immediate supervisor and subsequently the senior vice president to stop delivery of the flawed software. That in extremis course of action was discussed in small group settings immediately upon completion of the case by the student teams. The authors note that deliberate parallels were incorporated into the case with the Challenger space shuttle disaster, and Roger Boisjoly’s actions in attempting to stop or delay shuttle launches both prior to and during a telecon with lower-level NASA managers the night before the scheduled launch (Presidential Commission on the Space Shuttle Challenger Accident, 1986).

The multi-branched structure of the simulation follows from a few key decisions that students must make at various points through the activity. To get the students accustomed to the simulation structure and the scenario, the initial phase of the simulation, seen in Figure 4, presents them with a choice of raising a concern to the main actor’s supervisor regarding understaffing of the project. If they do raise the concern, they are presented with options that require them to choose between ignoring the concern and receiving a promotion or raising the issue and getting additional help but forgoing the promotion. Regardless of the decisions made in this section, all students are subsequently routed through the narrative associated with the bug discovery, as seen in Figure 1.

While the prior decisions only had a minor impact on the students’ scores, from this point on, the decisions cause the students to follow paths where the scores can be significantly different, mostly based on the ethical strength of the decisions. The first major decision the students encounter is whether to promptly report the bug to the main actor’s immediate supervisor, who happens to be on vacation at the time of discovery. If the students elect to take the more transparent route, they are routed through the logic in Figures 5 through 7. Where there are some differences in the wording and choices depending on whether or not the students elected for the earlier promotion, all of the paths lead into a sequence of events where the main actor’s resolve is tested. Initially the main actor is asked to sign off on a document containing an inaccurate certification and is subsequently pressured by superiors to let the signature of the main actor’s supervisor stand on
the document. The most ethical course of action is to continue to push to have the bug reported until ultimately reaching out to the FAA. Acceding to the company demands at any point prior leads to a story endpoint wherein a mid-air collision occurs and the company folds. Persisting all the way to reporting the problem to the FAA results in the avoidance of a crash and protecting the company from failure, though the outcome does mention the possibility of some subtle retaliation from within the company for the main actor’s whistle-blowing action.

Figures 8-10 illustrate the options if the students elect not to report the bug to the main actor’s supervisor right away. Again the exact storyline varies depending on the previous choices, but the students are confronted with decisions as to whether to work the weekend and then are pressured to sign or allow a fraudulent signature to stand on the document. The outcomes are the same as in the left-most branches, a mid-air collision or the successful whistle-blowing action.

There are three other outcomes that are possible on various branches of the story tree. Figure 7 illustrates two of them. The first is endpoint AK, which results from the main actor’s decision to quit the company to protest the supervisor’s pressure to fraudulently sign the certification document. The result is a plane crash, but without the main actor’s involvement in the certification process. For students who arrive here (and in hypothetical discussion during the debrief of the activity), there is a discussion of the fact that while the main actor did nothing specifically wrong, inaction still led to a loss of life.

Another unique outcome was outcome R, also shown in Figure 7, which results from an attempt to compromise. The storyline explains that the main actor and team have discovered the conditions that cause the bug to occur. These conditions are unlikely to occur in operation and so the main actor elects to include a message warning a user of possible inaccuracies. Since this still compromises the safety of the public, it is a less ethical choice. Furthermore, the signed certification is still fraudulent as the system does not meet the client’s specifications.

Finally, there is a set of choices illustrated in Figure 9 that lead to the main actor fixing the bug with a glaringly obvious solution and uploading the fixed code without notifying anyone. The main actor assumes that the final version of the code has not been delivered to the FAA when, in fact, the flawed version is sent instead of the patched version. As a result there is a plane crash, not due to the bug, but due to the lack of communication.

These three options were considered to be important to include, even if no students reached them, for instructional purposes. During the debrief, there was ample time to discuss these possibilities and process the associated ethical and professional concerns.
Narrative:
Almost two years have passed since the start of the project. Development of the software system has been completed, and the project delivery deadline is approaching. Final testing of the full system has begun with comprehensive simulations, and the testing follows a thorough protocol that is intended to test all realistic working conditions. You and two other engineers are conducting this final testing phase of the project, and all of you are now working many evenings because time is very short.

Near the end of the testing phase, your colleague noticed an apparent error, or bug, that occurred once. Under a certain set of circumstances with large numbers of aircraft that needed to be tracked, the software appeared to display incorrect altitudes of one or more aircraft for several minutes, then it recovered. The error was transient and subtle, and the data logs don’t match what your colleague saw on the screen. It’s not known what caused the error, or why it self-corrected. You realize the significant safety issues the error could potentially cause. You and the other two engineers involved in the testing phase discuss this bug, and all three of you focus your efforts on causing the bug to occur a second time. Testing continues for several more days, but none of you are able to produce the error again, and you’re reaching the end of the time allotted for testing. It’s now Tuesday, and the internal deadline for the bonus is next Monday, six days away.

The PM is on vacation this week in Mexico, though he left you a contact number for emergencies.

At this point, you have several options:

- Call the resort and arrange for a call with the PM. Inform him of the bug, being clear about the safety issue. Ask for more engineering help and/or more time for extended testing.
- Use the next six days for intense testing to isolate the bug. Wait to tell the PM about the bug until your team has verified and fixed it.

Restart
Consider the following in making your decision:

Stakeholders:
Your reporting this problem after it is solved makes you look a lot better.

PM: he needs this project to come in on time. May prefer to hear about a problem earlier than later. Then again, he may not want his vacation ruined worrying about a problem you and your team are working out.

Company: needs to turn over a safe product to the FAA on time, or risk missing out on next contract. This would be a huge impact to all employees of the company, including you.

Considerations:
The PM has not heard of any problems on the project, and is expecting things to go well during his vacation.
The PM was reckless and irresponsible for being gone during the final week of testing.
There is still a week left of testing time before the deadline, and in addition to you, there are several other software engineers also looking at the problem.

NSPE Canon:
1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statement only in an objective and truthful manner.
4. Avoid deceptive acts.
5. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

What tenets of the NSPE Canon apply to this decision?
Figure 2: Simulation screen shot showing a different narrative as well as the result after the students submit their choice.
Figure 3: Simulation flowchart showing the various branches and decision points. Note that this graphic is intended to illustrate the simulation structure; following figures provide detailed views of various branches with more legible text.
Figure 4: Introductory section of the simulation

Figure 5: Simulation flow following decision E on the more communicative branch
Figure 6: First two storyline endpoints
Figure 7: Next two storyline endpoints under the option to report issue to boss right away

Figure 8: Storyline options if students elect not to report bug to boss right away
Figure 9: Storyline options if students elect not to report to boss right away and takes the weekend off
Figure 10: Storyline options if the students elect not to report to boss right away but work through the weekend
The case was used in the introductory engineering course, required of all engineering majors, at Bucknell University in the fall semester of 2016. 208 first-year students were enrolled in the course; approximately 190 of them were engineering majors. Prior to the usage of the interactive simulation, one of the faculty members from the course presented a case study describing the technical and non-technical issues leading to the General Motors ignition switch legal suits and fines. This presentation was completed in lecture format and students were asked to complete a survey indicating their pre-simulation understanding of the ethics being taught. The following day, the first survey was closed and the interactive simulation was deployed within two-hour lab/recitation sessions with sections of 21 students (seven teams of three) and a faculty facilitator for each section. Upon completion of the case, the faculty facilitators led a discussion of the case, key decision points, and relevant sections of the NSPE Code of Ethics. The students were asked to complete a second survey to measure their post-simulation impressions.

The median student team score upon completing the case was six points, equal to their starting point total. No team achieved a perfect score of 10 points; nine points was the highest score achieved. Three teams received scores of zero points. The authors conclude that the case proved to be, by design, significantly challenging, forcing the students to struggle with their choices at many of the decision points.

Prior to starting the interactive case, the students were asked to complete a short evaluation form with seven questions, listed in Table 1. A response scale of 1 to 5 was used, with 5 being “strongly agree” and 1 being “strongly disagree.” The students were asked to complete the same form, with two open-ended questions appended to it, upon completion of the case. The two additional questions are:

- “What are the two most important concepts or lessons learned from this case study?”
- “What function or value is provided by the NSPE Code of Ethics in resolving ethical dilemmas?”

In accordance with Institutional Review Board (IRB) policies, students were able to complete or decline the survey without consequence. As a result, only 65 students completed the pre-case evaluation, and 44 students completed the post-case evaluation. Given the sample sizes, the results, summarized in Table 1, lack the statistical power to make conclusions about the effect of the activity on the queried items. However, anecdotal evidence from the five faculty instructors and the student responses to the open-ended questions suggest that there was significant value to the experience that was not reflected in the numerical responses.

Ideally, student responses to all seven questions (with the possible exception of the first and sixth) would shift toward the “disagree” (4) or “strongly disagree” (5) categories in the latter survey. Simple averages of the numeric scores shows little movement, though the number of students selecting “strongly agree” or “agree” did generally decline between the two surveys. The strongest result was the unexpected increase in agreement with the statement that “The correct decisions are those that minimize the cost to you, . . . ” This is likely a result of some of the specifics of the case wherein the students were, by connecting the outcome of the case to resisting
Table 1: Pre- and Post-Simulation Survey Data

<table>
<thead>
<tr>
<th>Evaluation Question</th>
<th>Pre-Simulation Mean Score / % Strongly Agree or Agree</th>
<th>Post-Simulation Mean Score / % Strongly Agree or Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>You should be able to anticipate the key impacts (positive or negative consequences) of your decisions on yourself and others at the time the decision(s) need to be made.</td>
<td>1.63 / 92%</td>
<td>1.75 / 89%</td>
</tr>
<tr>
<td>The NSPE Code of Ethics will provide you with a clear, conflict-free course of action in ethical dilemmas.</td>
<td>2.72 / 46%</td>
<td>2.98 / 43%</td>
</tr>
<tr>
<td>The correct decisions are those that minimize the cost to you, as you cannot control the actions of others, or be held responsible for their well-being. The correct decisions are those that are consistent with all expectations in the NSPE Code of Ethics.</td>
<td>3.65 / 20%</td>
<td>2.55 / 48%</td>
</tr>
<tr>
<td>As long as your decisions are ethically sound, your employer will support those decisions.</td>
<td>3.15 / 32%</td>
<td>3.39 / 20%</td>
</tr>
<tr>
<td>When faced with a decision having ethical implications, guidance from more senior personnel should be followed as they have greater experience in such issues.</td>
<td>2.54 / 52%</td>
<td>2.89 / 32%</td>
</tr>
<tr>
<td>The most ethically-sound decision will have the least personal cost to you.</td>
<td>3.72 / 9%</td>
<td>3.68 / 14%</td>
</tr>
</tbody>
</table>

Of greater interest than the numerical scores were the responses to the question “What are the two most important concepts or lessons learned from this case study?” in the post-case evaluation, and several are provided below.

“*That the “right” choice isn’t always black and white.*”

“*That the “right” choice will often require you yourself to give up something.*”

“*There are a lot of gray areas as you apply complex situations to how they effect a larger body as well as an individual. The other is that an individual may always feel the pressure to sway into unethical practices even if they seem small.*”

“*If you have a second thought about signing something… don’t sign it.*”

“*That just because you are not responsible for the result of an action does not mean that it is ethical.*”
“Doing the “right” thing may come at a great personal cost.”

“Moral courage is necessary. Doing the morally right thing has consequences, but those consequences are often times what one must face.”

“That the safety of others is exponentially more important than your commitment to a company.”

“First, I learned that sometimes the rough decisions, the ones that could hurt you and your family, are the right choices you have to make. ”

“Never simply assume that everyone thinks like you, that the mistake you will not make will not be made by others.”

“Another thing I learned is that people of power are not always correct.”

“That a decision that seems like a compromise may still be an unethical decision.”

“You are responsible at all points for something you made or did, even if you don’t sign off on it.”

“Sometimes it is better to do what is not the best for you if that is the most ethical decision.”

“That sometimes, compromise isn’t the best solution. There will be people (and bosses) who try to convince you to do something unethical simply because it [benefits them].”

“That there is much more to making decisions than one would think when it comes to engineering. Also, making decisions based on moral codes and what your boss wants might result in different decisions being made.”

“That the ethical decision will often times come with a personal cost to yourself and that not everyone will want and do what’s ethical.”

And then there were the following:

“When being faced with an ethical dilemma, you are going to lose either way. You just have to pick the option in which you lose the least.”

“Employers do not like people who are concerned about every single minor problem.”

“Being good at convincing people is just as important as being ethical.”

Following completion of the interactive case by the student teams, a small-group discussion was facilitated by a faculty member in each section. Given the course enrollment, five separate faculty served as facilitators, and the content of those discussions likely varied from one section to the next. However, the facilitators reported that the student teams were engaged in the case, and many and often lively discussions within the teams occurred at each decision point. They concluded that the case was largely successful, and will not hesitate to incorporate it into future offerings of the course. It is apparent, however, that ethical competency cannot be achieved through the use and discussion, spanning some two hours, of a single interactive ethics case.
**Future Case Development**

While the interactive case was judged an effective instrument in challenging and engaging students with complex ethical dilemmas, the authors are evaluating several modifications prior to its use again in the introductory engineering course.

The current version of the case describes a software bug that is transient, occurring only once during testing, is apparently self-correcting, and could not be induced to occur a second time, albeit in a short time frame. It also states that the error did not appear in the data logs of the tests. This raises the possibility that the bug does not in fact exist; the main actor in the case might have erred in what he or she believed to have witnessed during the tests. For students at the first-year level, it may be more effective if there is no doubt as to the existence of the bug; the probability of its reoccurrence, and the potential for catastrophic consequences should it reoccur, would remain uncertain. It is expected that student scores would rise slightly as a result of this change, as it eliminates an especially difficult element of the case.

There are a few branches within the case that are relatively short, reachable through a relatively small number of consistently poor choices by the student teams, and those teams do not currently have the opportunity to re-engage the case and work through the remaining sections and decision points. Modifying the flow of the case to permit re-engagement would be beneficial for those teams (relatively few in number), and the initial point penalties incurred could be maintained or adjusted as appropriate.

The case was implemented in ten sections, with subsequent discussions led by five faculty facilitators. In the future, a more explicit outline of the ethical points in the case to be addressed in the discussion will be developed. The authors further note that they did not share the seven evaluation questions with the faculty facilitators to insure that only the students’ experience with the interactive case itself would influence the post-case evaluations. However, appropriate answers to those questions are important to the students’ understanding of, and responses to, the ethical dilemmas they are likely to experience in the future, so they will be included in the discussion points in future uses of the case.

Individual student scores are recorded by the web application, and students are permitted to form their own teams immediately prior to entering the case. For that purpose, students are required to enter the email addresses of their teammates at the start of the case, and that proved to be less than fully reliable. Future use of the case will need a different mechanism to track individual student scores, such as through the direct assignment of team members to each team prior to the case.

**Conclusions**

The interactive ethics case employed during the fall 2016 semester in the introductory engineering course was successful in challenging student teams in addressing a complex case study having multiple sequential decision points, and significant levels of uncertainty in the probability of a negative outcome. At the same time, the students easily related to the case
concept that centered on a software bug, and many could envision themselves in a similar employment scenario. The interactive implementation of the case, along with grade additions or penalties at each decision point, engaged the students at a level, in the authors’ opinion, significantly above that obtained with a traditional case study.

The case offers the following primary advantages from an educational and student engagement perspective:

- The interactive implementation through a web application is effective in engaging students in the case and the ethical dilemmas within it;
- The case requires students to progress through a series of decisions with increasing risk of a negative outcome, and for personal cost to the main actor;
- The case offers challenging ethical issues that need to be addressed, and the potential for a significant negative outcome: loss of human life. At the same time, students can readily identify with the case concept and employment scenario;
- Undertaken by student teams, the case stimulates discussion while the immediate grade impact of each decision is effective in engaging all students on the team.

The advantages of an interactive implementation through a web application are not limited to this particular case; the concept can be applied to a wide range of ethics case studies.

Acknowledgements

The authors wish to acknowledge the important conceptual and developmental work on the interactive case provided by Emily Geist, Assistant Professor of Mechanical Engineering at Bucknell University during that time. The authors also wish to thank Diane Jakacki and Luyang Ren, Library & Information Technology professional staff at the university who aided in the development of the web implementation of this case, and the many faculty facilitators who undertook the implementation of the case and led the subsequent discussions. The authors also wish to thank the Kern Family Foundation for its financial support of this work.
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