A Simulation for Exploring Ethical Situations that Arise from Conflicting Product Goals

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A Simulation System for Exploring Ethical Situations that Arise from Conflicting Engineering Team Goals

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Abstract
Engineering ethics is a difficult topic for educators as the most difficult ethical situations that our students will likely face as future engineers will be nuanced and unclear. A simulation of an engineering team resolving a potential safety problem, the 1960 Corvair suspension design, has been created in an effort to create a realistic situation where the ethical difficulties arise from the conflicting demands of engineering teams. A realistic engineering team is created with conflicting goals assigned to students and simulated using modified commercial role-playing game (RPG) mechanics to recreate realistic interpersonal and engineering skills to create a rich and nuanced ethical environment. The RPG mechanics also allow the instructor to imbalance the simulation towards a desired outcome. The team roles and RPG mechanics will be presented along with options for the instructor to influence the simulation outcome. A class reflective exercise that allows students to process the interactions and to discuss the consequences of the outcomes for real-life engineers and engineering teams will also be presented. An assessment tool has been developed based on previous ethical and game assessment tools to determine the effectiveness of this approach.

Introduction

Some of the most challenging ethical situations are those that the ethical conundrum is not clear or arises from competing demands that are not, in and of themselves, moral or ethical decisions. Putting students into those situations without the subsequent consequences to their job, career, or psyche allows them to explore the causes of and alternatives within realistic ethical situations in addition to the consequences.

Role-playing games (RPGs) allow players to assume the role of the character they are playing, their player character (PC), and act in the game world as if they were their PC. Research has shown that RPGs can be experienced so realistically that players even store memories from games in the same region of the brain that they store events that happen in real-life [1]. They have been shown to be effective in phycological therapy [2], in college education [3,4], and in particular by the Reacting to the Past consortium [5], primarily in history and humanities education. A modified version of the Fate™ RPG has been used to simulate meeting dynamics to allow students to play in a simulation of a meeting to decide the suspension design for an imaginary product similar to the choices made for the 1960 Corvair suspension design that lead to injuries and fatalities [6]. Fate was chosen due to its ease of use, simple mechanics, and the ability to impact the simulation outcomes due to the probability distribution of the Fudge dice used with it.

It may seem odd to use game mechanics that incorporate chance into an ethics game. Each PC has a different set of skills, simulating the reality they will face in their career, and the game mechanics require students to decide which of their PC's skills they use to persuade, argue with, or intimidate the other PCs. The dice rolls made when using these skills do not take away the students's agency - they still decide which skills to use and in what way they will be used - but introduce a random element, making the outcomes uncertain. The Fate mechanics were selected to allow for an asymmetric power dynamic due to the probability distribution of the Fudge dice used in the Fate™ RPG. Fudge dice are six sided dice with two faces with a "+", two with a "-", and two blank faces. Four dice are rolled and the face results are added, with the most probable results (about 72% likely) of a +1, 0, or -1, meaning that the instructor/game designer can have a significant impact on the outcome via skill assignment to the players' characters. To allow for the simulation to be pushed toward a more difficult outcome for the engineers (and a more ethically interesting scenario), "Reputation" is added to the business side in the form of a poker chip that is worth +2 or a re-roll of the dice. With the Fudge dice probability, this is significant advantage and is given to those who seek the least expensive solution to the problem.

The simulation centers on a meeting about how to proceed with the company's new product (code named "YS" in the simulation) that promises to regain market share lost to competitors and attract the young buyers that are crucial to the future of the company. The project goals for the YS have resulted in a design that is bold and innovative but that has proven to be a challenge for many parts of the company. The central conflict is that Suspension and Chassis groups have found a dynamic instability in the vehicle handling that could result in a roll-over. This is of particular concern for the less-experienced drivers who are the target buyers. The other groups are frustrated with the design changes and associated delays that have come with the completely new design and an engineering team proposes a simple fix that is attractive but not all that it seems. The game mechanics create a significant challenge for the engineers that hope to prevent potential injuries.

Simulation Overview

The simulation is run in two parts, with the second part being a repeat of the first part with an added simulation element before the meeting simulation. It is run in two parts to allow the students the opportunity to "retcon" (retroactive continuity – a retroactive revision of the outcome of the first part) to repeat the results of the first part. The two parts allow for a deeper experience and reduce frustration with misunderstandings of the game mechanics.

The first part of the simulation starts with an introduction to the simulation scenario (see Appendix A), a brief description of the company structure, introduction of each PC by the player, and a few examples of game mechanics in action. The instructor acts as the project manager and convenes the meeting to discuss a proposed change to the suspension system. Each PC has a title within the company, a background, and an objective and the meeting begins with each project team stating its status on the project and its concerns about the project. Discussion commences and the conflict mechanics are used when a player wishes their PC to either challenge or persuade another PC. The PC titles and objectives are in Table 1 along with their skill and

reputation chips (the number of +2/re-roll bonuses allowed to each player) which will be discussed in Simulation Mechanics.

The central conflict within the meeting simulation is between the Suspension and Chassis engineers who advocate a modification to the suspension to prevent potentially deadly vehicle roll-overs, business-side PCs who are tired of constant design changes, and the Body engineering team that has found a solution to the roll-overs while they were testing for a quieter vehicle ride. the Body Group's solution is to reduce the pressure of the front tires, the same solution proposed on the Corvair [6]; the problem is that once the tires need to be re-inflated, there is no guarantee that the customer will inflate to the correct pressure.

Title	Objective	Highest Skill	Reputation Chips
Marketing Director	Rush production	+4	1
Senior VP Purchasing	No new components	+4	3
VP Sales	Maintain schedule	+4	3
Quality Chief Engineer	No new components	+3	2
Purchasing Manager	No new components	+4	2
Manufacturing Plant Manager	No new components Maintain schedule	+4	2
Chassis Senior Engineer	New stabilizer bar	+3	0
Body Chief Engineer	Reduce tire pressure	+4	2
Suspension Senior Engineer	New stabilizer bar	+3	1
Suspension Junior Engineer	New stabilizer bar	+2	0

Table 1: PC Roles and their objectives, skills, and reputation chips

The simulation concludes once all PCs agree as to the best project decision; the simulation mechanics, especially the PCs with "Reputation," make it likely that the tire pressure will be the final compromise. After the solution is decided, a debriefing discussion allows for discussion of what happened within the game, possible alternative choices, how PCs could pursue better outcomes within the company, and how the students might deal with a similar situation themselves.

The second part begins after a short break and begins with a discussion about how the engineers would have foreseen the possible outcomes (due to their experience in the company) and they are provided with an opportunity to prepare for the meeting via research, testing, presentation preparation, etc. so that they may gain "Data" that is mechanically the same as Reputation and allows greater parity for the engineers. The meeting simulation is then run again (possibly with a different outcome than the first meeting) followed by another debrief. The second meeting goes

much faster that the first as each player is familiar with their own and other PC's arguments and also with the simulation mechanics. Allowing players to get a second opportunity has proven to be positive and the addition of the Data chips, with the same benefits as Reputation Chips, emphasizes how engineers have the power to sway discussions.

Roles

One anticipated benefit of this approach is to have players consider the many perspectives of the other portions of the company. Playing managers, VPs, and manufacturing personnel will hopefully allow them to see and better understand the alternative perspectives that they will encounter in industry. It is also hoped that this will provide insight into realistic ethical conflicts as well as how students might proceed if they find themselves in a meeting making a similar decision. The debriefs have proven to bring out a variety of responses and allow for an open discussion as to how they might proceed were they to find themselves in a similar position.

Simulation Mechanics

To simulate realistic meeting skills, a collection of skills are assigned to each PC for the meetings in Parts 1 & 2 ("Meeting Skills" in Table 2) and a different set of skills assigned to each group in the Project Work that proceeds the meeting in Part 2 ("Project Work Skills" in Table 2). Each skill is assigned a value of +1 to +3 or +4, depending on the PC (+3 is the maximum for less experienced PCs), allowing a broad range of skills and levels. The skills are added to a PC's action and the defending PC must also use a skill to defend themselves and can also be added to a die roll to assist other PCs. Each skill can only be used once each meeting. It is hypothesized that the skills allow players to not worry about making the correct arguments, speaking well, etc. but to see themselves as their PC and having their PC's skills. The group skills are assigned so that each group has different skills that correspond to their function within the company.

One skill, Intimidate, has unique capabilities in that when it is successfully used against another PC, it adds to their Mental Stress track, simulating the psychological impact. After one Mental Stress, a PC is incapable of acting or defending themselves for the next round of actions, leaving them vulnerable to attack and incapable of assisting others. If they receive two Mental Stress, they must leave for the remainder of the meeting (the PC, not the player – the player may stay). If a player chooses to use Intimidate and it fails, they automatically receive two Mental Stress and their PC must leave the meeting to simulate the emotional impact of a failed intimidation attempt (and to discourage its use).

The final modifier to die rolls are Reputation and Data chips. To allow for the simulation to be pushed toward a more difficult outcome for the engineers (and a more ethically interesting scenario), "Reputation Chips" and "Data Chips" are added in the form of a poker chip that is worth +2 or a re-roll of the dice, providing a significant advantage with the Fudge dice probability, allowing the instructor to imbalance the simulation as desired. The player can use these modifiers chips by adding them to a roll or forcing a re-roll as many times as they have chips, giving a significant potential advantage to those with Reputation or Data. Reputation simulates the PC standing within the company and their ability to use that to sway decisions

within the company. Note that the business side players have more reputation and thus more ability to achieve their objectives. During Part 2, the engineers can try to match this power by collecting data and doing research and testing, providing them with Data Chips that price them with additional power to create a different outcome the second time around.

See Appendix B for the complete PC and group sheets.

Project Work Skills:	**Meeting Skills:**
Analysis	Intimidate
Testing	Business Analysis
Research	Reason
Simulation	Stubborn
Presentation Preparation	Persuade
Marketing Analysis	Technology
Supplier Resourcing	Marketing Analysis
Customer Satisfaction Research	Resist
Six Sigma Analysis	
Poka-Yoke	
Lean Manufacturing	

Table 2: Project Work Skills and Meeting Skills

Simulation Procedure

The simulation was performed in two sections of mechanical engineering capstone design during the second quarter of a three quarter senior design sequence. After a brief introduction to the Fate™ game mechanics, the meeting is convened, each student introduces their PC, describes their role, and explains their team's status. Discussions ensue as to the best course of action and once conflicts arise, the dice, PC skills, and reputation chips resolve the disputes. The outcome is almost certainly an ethical compromise that has the potential to impact the customers' safety, the value of the product, and the company's reputation.

After a brief discussion, the engineers are told that they most certainly would have foreseen the potential failure and would have prepared. They are then given the opportunity to do "research" and "testing" (by rolling dice and using their engineering skill modifiers) to accumulate "Data" – poker chips that act the same as reputation in the game. The meeting is held again with another,

longer debrief. Ethical frameworks are not mentioned nor is any specific ethical theory. The conversations center on what happened, how it might have been prevented, and how the students might respond in a similar situation.

Assessment Parameters

There are five parameters that were assessed in the simulation. Two were to assess the ethical performance, two for the game play, and one to measure the broader impacts. Some parameters were assessed via observation during the simulation and others via evaluation of post-simulation reflective statements. Table 3 contains the parameters, their assessment area, and assessment method.

The ethical parameters assess each students ability to recognize the potential impacts of their decisions on society and their ability to identify a framework to ethically resolve the conundrum. Both were evaluated via student comments in a reflective exercise and are rated on a Likert scale using the guidelines in Table 4. The ethic assessment criteria (Criteria 1) was taken directly from the ethics assessment criteria used at our university assessment of student outcomes. The ethical framework (Criteria 2) is a modified version of ethical frameworks from reference [7]. The responses are assigned to consequence-, care-, duty-, and/or virtue-based frameworks based on keywords in their reflection response.

Criteria 3 assesses each student's immersion in their character (PC), how well they use the goals given to their PC as part of the simulation and was created to test how well players identified with their PCs via how well they use the game mechanics to achieve their PC's goals This criteria was created to determine how much each player identified with their PC, something indicated in RPG research [1]. Criteria 4 & 5 were adapted from previous role-playing course assessments for learning outcomes and student behaviors [8] used by the Reacting to the Past consortium (RTTP).

Parameter Type	Assessment	Assessment Method
1. Ethical	Recognition of societal and economic impacts	Post-simulation reflection
2. Ethical	Application of a framework to identify ethical resolution	Post-simulation reflection
3. Simulation	Student acts in keeping with their PC's goals	During Simulation
4. Simulation	Considers multiple perspectives	Simulation and Post-simulation assessment
5. Overall	Considers broader perspectives and impacts	Post-simulation assessment

Table 3: Assessment Parameters, their type, and their assessment method.

Assessment Results

The average results for each section are presented in Table 5 using the assessment criteria from Table 4; relevant student comments are presented below. The overall results are positive and the most interesting result was that all students correctly identified an ethical framework and a resolution method even though no course or simulation discussion or lecture/reading content explained ethical frameworks or any other formal ethics theory. While there is no control group, the simulation approach appears to have been effective in exploring ethical problems and the associated resolution methods but also in helping students consider perspectives other than their own/their own teams'. Additional studies will be undertaken to determine the level of identification that the student has with their PC and the associated impact on their actions.

Select student comments:

- "This was much better than the case studies we use in other classes."
- "This was a great experience that opened my eyes."
- "I hope we can do this again for a different problem."
- "I didn't realize real-world engineering decisions were made like this."

Likert Score	1.Recognition of societal and economic impacts	2.Application of a framework to identify ethical resolution	3. Student acts in keeping with their PC's goals	4. Considers multiple perspectives	5. Considers broader perspectives
5	Two or more examples for each	Identifies framework, resolution mechanism	Uses game mechanics, PC background, and improvises in character	Identifies viewpoints of two other teams with connection to their goal or crisis	Identifies three or more other groups' perspectives and the impact on their action in the simulation
4	Two examples for one, one for another	Identifies framework	Uses game mechanics, and PC background	Identifies viewpoints of one other teams with connection to their goal or crisis	Identifies three or more other groups' perspectives and the impact of at least one.
3	One example for each	Identifies resolution mechanism	Uses game mechanics	Identifies viewpoints of two other teams	Identifies two or more other groups' perspectives and the impact on their action in the simulation
2	Two examples of either	Identifies key ethical crisis	Uses PC background	Identifies viewpoints of one other team	Identifies two or more other groups' perspectives
1	One example of either	Identifies ethical problems	Uses PC background	Recognizes that other views were present	Identifies one or no other groups' perspectives

Table 2: Assessment parameters, Likert scale, and associated rating guidelines

Conclusions

The simulation was effective in helping students identify a framework for resolution, recognize the potential impacts of their decision, as well as consider the perspectives of other company groups within the meeting. Students in the simulations have even correctly identified moral frameworks even though none were formally presented. The assessment results and the qualitative student response show the benefits of this simulation technique over the previous capstone case study approach. These results have been so encouraging that the capstone faculty have chosen this technique for all ethics instruction at Rose-Hulman.

Section\Criteria	1.Recognition of societal and economic impacts	2.Application of a framework to identify ethical resolution	3.Student acts in keeping with their PC's goals	4.Considers multiple perspectives	5.Considers broader perspectives
Section 1	4.2	5	4.6	4.2	4.6
Section 2	3.9	5	3.9	3.9	4.3

Table 5: Assessment Results

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Appendix A: Simulation introduction provided to players

Your company, RH Motors, is the dominant company in the U.S. auto industry but lately your competitors have been taking your youngest customers with their new products. This is a challenge to your company because young buyers often become loyal to their first new car brand. Also, your dealers have been demanding a competitive product to get customers from their competitors. Your company has planned a bold new design, code named YS, that is a completely new design – new engine, new chassis, new suspension. All of these new components have created challenges in engineering and manufacturing that are threatening to delay the project. You have been called to a meeting to finalize the design of the YS so that manufacturing won't be delayed but first you need to decide as a team if a new suspension component, called a sway bar, will be added to the YS. The Large Project Lead has called a meeting to make the decision. You are six weeks from the design freeze deadline.

Appendix B: Skills sheets for PCs and for Project Teams