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Workshop: Gamifying Engineering Education - A Playful Approach to First-Year Ethics Instruction

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Daniel Burkey is the Associate Dean of Undergraduate Programs and Professor-in-Residence in the Department of Chemical and Biomolecular Engineering at the University of Connecticut. He received his B.S. in chemical engineering from Lehigh University in 1998, and his M.S.C.E.P and Ph.D. in chemical engineering from the Massachusetts Institute of Technology in 2000 and 2003, respectively. His primary areas of interest are game-based education, engineering ethics, and process safety education.

Prof. Michael F Young

Dr. Young (http://myoung.education.uconn.edu/) received his PhD from Vanderbilt University in Cognitive Psychology and directs UConn's 2 Summers in Learning Technology program. He is the author of nine chapters on an ecological psychology approach to instructional design and has authored more than two dozen peer reviewed research papers. His work has appeared in many major journals including the Journal of Educational Computing Research, the Journal of the Learning Sciences, the Journal of Research on Science Teaching, Instructional Science, and Educational Technology Research and Development. Mike's research concerns how people think and learning, and specifically how technology can enhance the way people think and learn. His NSF-funded project, GEEWIS (http://www.geewis.uconn.edu/), focused on streaming real-time water quality pond data via the Internet and providing support for the integration of this authentic data into secondary and higher education science classrooms. His work with The Beamer (https://thestardustmystery.com/thebeamer-llc/), supported the design/development of playful VR science environments for middle schoolers. His approach features the analysis of log files, "dribble files," that maintain time-stamped listing of navigation choices and lag time. This approach has been applied to hypertext reading (Spencer Foundation grant), videodisc-based problem solving (Jasper project), and online navigation (Jason project). Recent work concerns playful learning using video game, card games, and board games aligned with national teaching and learning standards.

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Jennifer Pascal is an Associate Professor in Residence at the University of Connecticut. She earned her PhD from Tennessee Technological University in 2011 and was then an NIH Academic Science Education and Research Training (ASERT) Postdoctoral Fellow at the University of New Mexico. Her research interests include the integration of fine arts and engineering and developing effective methods to teach transport phenomena.

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Through both success and failure, many engineering projects have a profound impact on individuals and society. Thus, ensuring future engineers consider these impacts and reflect on the ethical implications of their future work is an extremely important topic. There are many pitfalls with the traditional ways in which ethics is taught to engineering students. Often it is taught by a non-engineer as an abstract philosophical topic, rather than an act of personal decision making situated in complex real-world contexts. . It is usually included late in the undergraduate curriculum, such as during a senior capstone project, and is a relatively short subtopic (module) within a larger array of engineering content. As a result, students often do not see ethics as equally important or connected to other topics. They do not see it consistently integrated throughout the curriculum, nor do they see ethical decisions as complex, nuanced, and situated in varying political and economic contexts in which engineering takes place.

We contend a better alternative would be to address engineering ethics not solely in the abstract of philosophy or moral development, but as situated in the everyday decisions of engineers as they do their work. Since such everyday decisions are not a part of university courses, one alternative is to simulate engineering decision-making situations with scenarios or the presentation of ethical dilemmas drawn from real life cases. This can often put students in the position of searching for the "right ethical response," rather than applying their personal ethic toward reasoning through various contingencies and trade-offs to determine their best path to solution in a particular moment. Drawing on the contemporary learning theory of situated learning [1][2], playful learning may enable instructors to create assignments that enable students to break free of the typical student mindset of finding the "right" answer, and use various game mechanics to induce them to act more as themselves, as they would on-the-fly within a real engineering project context, drawing on personal reasoning and justifications, rather than simply right/wrong answers.

Our work is based on the logic that game-based learning can provide a means to engage students actively in interrogating the complexities of ethical decision making in specific engineering scenarios. Game play can align with engineering course learning objectives as well as enhance student knowledge, behaviors, and dispositions as students reflect on their own decision making and that of their peers [3]. **This workshop paper will provide an overview of three games that we designed as part of an NSF-funded project investigating the impacts of game play on ethical reasoning and decision making, highlighting the concepts that guided our approach to innovative engineering ethics instruction.** Each game targets specific ethics learning outcomes such as:

- Identifying the complexities of ethical dilemmas
- Evaluating responses to ethical situations in context
- Promoting ethical discussions among peers on potentially controversial situations from real-life engineering disasters

The three "playful assignments" (i.e., games) that we developed to address the various student learning outcomes have different play mechanisms and time requirements, ranging from a 20 minute card game to

multi-week choose-your-own adventure narrative. All three games have been developed (or refined) during the COVID-19 pandemic, and thus can be played in a completely remote environment or in-person if desired. **In this workshop, we will provide an overview of all three games, how they can be implemented in both remote and in-person classroom settings, and how to gain access to the materials (and instructional guides). We will also share some preliminary research on the benefits of a playful learning approach to ethics instruction and the frameworks that guided the game design**. More details about the NSF grant, the research team, and the games can be found at https://sites.google.com/view/engineering-ethics/home and also [4] and[5].

Cards Against Engineering Ethics (CAEE)

The first game is Cards Against Engineering Ethics (CAEE). Designed as an analog to the popular card games Cards Against Humanity and Apples to Apples, CAEE contextualizes its card choices within an engineering ethical framework. Prompt cards and response cards draw from literature and cultural sources of engineering ethical dilemmas and real life engineering disasters, as well as personal experiences of the research team. For example, one prompt card references the Apollo 13 oxygen tank failure with the text "The crew of the Apollo 13 should have used _____ to fix the oxygen tanks", with the underscore being where the response card would fill in. Students would then look at their hand of response cards to find one that could best fit. Response cards range from "Artificial Intelligence" and "Gorilla Glue" to "Aliens," "The BP Oil Spill," "Albert Einstein," and "Your Mom." Play is dynamic, and can be accomplished in groups of varying size and for varying amounts of time, allowing it to be deployed in a classroom setting or given as an out-of-class assignment. For in-person play, cards are printed and distributed to students, and for online play, the game has been ported to an online portal (https://not.allbad.cards/), which allows the game to be played among participants virtually using our custom deck of cards, wherever they may be.

Toxic Workplaces: A Cooperative Ethics Card Game

Toxic Workplaces is a scenario-based card game that requires the players to evaluate an engineering ethics dilemma, and then collaboratively evaluate potential responses to that scenario. The game itself contains data from a first-year engineering student survey of those same ethical dilemmas. Each choice contains a secret percentage, how many first-year engineering students chose that option. It is up to the players to rearrange the options from most picked to least picked. In some ways this parallels the play of the TV game *Family Feud* in which players are asked to anticipate what "the survey says…" are the top survey responses to a prompt. The players need to put themselves in first-year engineering students' shoes and try and imagine what they would prioritize. The players win if they can successfully organize the responses from most picked to least picked. Afterwards, we ask the students to reflect amongst themselves with some questions. What strategies did they use to justify their ordering? Are these ethical scenarios similar to ones you experience in your everyday life? How might they be different? A full Toxic Workplaces game and reflection can take up to 75 minutes. The game is designed to prompt players to not only consider what they would do in an ethical scenario, but also have them imagine what other first year engineering students chose. This reflection on the ethics of first year students may also be contrasted with the ethics of more experienced engineers. The format of this game encourages collective discussion of the scenario and the potential

actions, as well as discussion of potential conflicts that emerge when the player-chosen ordering differs from the actual ordering of the responses. This game has also been ported to an online format using Google Slides to allow players to manipulate shared tokens in a collectively accessed document to allow for online play.

Choose Your Own Adventure (CYOA): Mars - An Ethical Expedition

The third game developed by this collaboration is called Mars: An Ethical Expedition. As compared to the other two games, the CYOA game unfolds over a series of chapters in a typical narrative arc. Each week students are presented with an ethical dilemma contextualized within the narrative of the students being a new engineering team recently arrived on Mars as part of a colonization expedition. The narrative arc can evolve and present different choices to students based on the collective response to the weekly scenario, which students will provide via student-response software (i.e. clickers) or via their learning management system (LMS). The dilemmas can range from potential life or death adventures to more mundane scenarios. Should they let an infected individual onto the colony? Do they choose to spend time comforting a co worker instead of finding the saboteur? After each chapter, the players vote on the path before them and the option with a majority is chosen to progress the story. After each vote, the players are then asked some follow up questions pertaining to their choice. These can range from more personal statements such as "Do you enjoy working in a group?" to weighty ethical dilemmas such as "Is it okay to bring harm to a sentient being for the good of the colony?". This game will hopefully show players that ethical dilemmas show up in their everyday life and not just as these major life or death moments. A student team at one of the grantee universities is working on the development of this game and ported it to an online, story-telling portal (https://twinery.org/).

Instructional Implications

All of these games were used remotely during the Spring 2021 semester in various combinations at the participating institutions. We are designing these 3 games in hopes of increasing the engagement of typical freshmen engineers, often in large lecture settings, by inviting them to consider their ethical behavior in the context of game play. By providing students license to explore their ethical thinking in the context of playful responses and role playing, these assignments are designed to encourage students to think and act as they might on the job, rather than within the constraints of a graded university course. Our work to evaluate these games is ongoing and includes questions about typical moral reasoning measures (DIT2 and EERI) as well as the impact on the quality of student think aloud reasoning, their conceptual development as indicated by concept maps, and their overall interest and engagement with game play as experienced as playful and thought provoking. **The workshop, in addition to describing and providing instructional guides to the games, will provide some preliminary results from this evaluative research.**

References

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