Board 399: The Affordances of Playful Learning in Ethics Education: Challenging the Status Quo

Dr. Scott Streiner, University of Pittsburgh

Scott Streiner is an Assistant Professor in the Industrial Engineering Department, teaches in the First-Year Engineering Program and works in the Engineering Education Research Center (EERC) in the Swanson School of Engineering at the University of Pittsburgh. Scott has received funding through NSF to conduct research on the impact of game-based learning on the development of first-year students' ethical reasoning, as well as research on the development of culturally responsive ethics education in global contexts. He is an active member of the Kern Engineering Entrepreneurship Network (KEEN), the American Society for Engineering Education (ASEE), and the Institute of Industrial and Systems Engineers (IISE)

Dr. Daniel D. Burkey, University of Connecticut

Daniel Burkey is the Associate Dean of Undergraduate Programs and the Castleman Term Professor in Engineering Innovation in the College of Engineering at the University of Connecticut. He earned his B.S. in Chemical Engineering from Lehigh University in 1998, his M.S.C.E.P and Ph.D., both in Chemical Engineering, from the Massachusetts Institute of Technology in 2000 an 2003, respectively, and his M.A.Ed with a focus in Research Methods, Measurement, and Evaluation from the University of Connecticut in 2023.

Dr. Kevin D. Dahm, Rowan University

Kevin Dahm is a Professor of Chemical Engineering at Rowan University. He earned his BS from Worcester Polytechnic Institute (92) and his PhD from Massachusetts Institute of Technology (98). He has published two books, "Fundamentals of Chemical Engineer

Dr. Richard Tyler Cimino, New Jersey Institute of Technology

Dr. Richard T. Cimino is a Senior Lecturer in the Otto H. York Department of Chemical and Materials Engineering at New Jersey Institute of Technology. His research interests include the intersection of engineering ethics and process safety, and broadening inclusion in engineering, with a focus on the LGBTQ+ community.

Tori Wagner, University of Connecticut

Tori Wagner is a doctoral student at the University of Connecticut studying Learning Sciences. She has a background in secondary science education, playful learning, and digital game design.

The Affordances of Playful Learning in Ethics Education: Challenging the Status Quo [NSF Grantee Poster Paper]

Abstract

Ethics education has been recognized as increasingly important to engineering over the past two decades, although disagreement exists concerning how ethics can and should be taught in the classroom. With the support from the National Science Foundation (NSF) Improving Undergraduate STEM Education (IUSE) program, a collaboration of investigators from the University of Connecticut, New Jersey Institute of Technology, University of Pittsburgh, and Rowan University are conducting a mixed-methods project investigating how game-based or playful learning *with strongly situated components* can influence first-year engineering students' ethical knowledge, awareness, and decision making.

The popularity and prevalence of game-based or "playful" learning strategies has grown significantly over the past two decades, finding applications in a diverse range of educational contexts. Playful learning offers unique affordances for the practical assessment of ethics learning outcomes. Current ethical assessments often place undue emphasis on the categorization of knowledge and skills, while not sufficiently addressing the process through which students navigate and act on ethical dilemmas. This, we posit, is an area that needs redefining, given that ethical decision-making is rarely a linear process with single objective "right" answers and often involves iterative reasoning and interactive engagement with the problem. As such, we have developed a suite of ethics-driven classroom games that have been implemented and evaluated across three universities, engaging over 400 first-year engineering students over the past 3 years. Now in the grant's final year, we are finishing the design of two of the game-based ethics interventions to (1) more accurately align with the ethical dilemmas in the Engineering Ethics Reasoning Instrument (EERI), (2) allow for more flexibility in modality of how the games are distributed to faculty and students, and (3) provide more variety in terms of the contexts of ethical dilemmas as well as types of dilemmas.

In this paper, we will summarize our findings to date, address the application of playful learning to engineering ethics education, and review some key challenges to successful implementation of playful learning. We assert that playful learning environments can afford the assessment of ethical decision making as a first-person interaction and engagement with dynamic information in the world. Challenging the status quo and redefining the teaching and learning of engineering ethics will open up a plethora of new research opportunities and should prompt a deeper, more critical engagement with the development of ethical engineers.

Introduction

[Sections labeled "Introduction" and "Overview of the Work" are reprinted from the 2021 ASEE Poster Session Paper which provides preliminary material for the reader.] [1]

Over the past twenty years, there has been a strong shift in the scope of US undergraduate engineering programs towards heightening students' awareness of the professional, social and ethical aspects of the profession. The impetus for this shift has come largely from professional societies and sources of accreditation (such as ABET) in response to numerous high profile engineering failures that have underscored the ethical implications of engineering in the broadening cross-cultural context. Many of these widely publicized failures of complex engineering systems can be traced back to lapses in judgment on either ethical or societal impact axes, including the Volkswagen Diesel Engine scandal, the BP Gulf Oil Spill, the Challenger and Columbia space shuttle disasters, the Flint, Michigan Water Crisis, the Florida International University Bridge Collapse, and the Boeing 737-MAX accidents [2-8]. There is NSF-sponsored research that suggests that emphasizing the local and social impact of engineering, and particularly its contributions to health, happiness and safety, may have an important role in attracting and retaining prospective engineers [9]. Even though more ethical skills training interventions are being developed across the US engineering curricula, many engineering programs still do not address these socially impactful issues in formal ways in their curricula.

This multi-phase research initiative aims to both measure and influence early-curriculum engineering students' ethical awareness and reasoning through the use of game-based educational interventions with strongly situated social components. We believe that situating the exploration of engineering ethical challenges and reasoning in a game-based context is a novel way of influencing how students perceive and react to ethical dilemmas. Giving students the opportunity during their education to recognize the wider social and ethical impacts of the profession - through multimedia simulation, role-playing games, case-based learning, and review of other, fictionalized cases - can give them opportunities to reflect on the need to identify complex situations in future settings, as well as a safe environment in which to explore, make mistakes, and discuss the ramifications of various decisions in authentic contexts. Ultimately the goal is to better prepare young engineers to tackle current and future challenges that have tended to be underemphasized in traditional engineering curricula.

The overall research question for this project is "*In what ways can experiential, game-based approaches to engineering ethics improve students' ethical reasoning skills?"* The authors have developed a suite of game-based ethical interventions for use in undergraduate engineering classrooms (virtual or otherwise) that incorporate different mechanisms of play and timescales and provide students with multiple opportunities and ways to engage course materials. Observational studies of the student play experiences within the context of engineering ethical reasoning will be

undertaken to further explore student thought processes and approaches to ethical scenarios. In addition, these interventions will be paired with a mixed-method, within-groups, change-over-time evaluation and assessment strategy for determining ethical awareness and reasoning ability and the impact the interventions have on various learning outcomes. This paper provides an overview of the research endeavor, a description of the games developed, preliminary assessment results, lessons learned, and next steps.

Overview of the Work

There are three primary objectives of this research project:

1. Characterize the ethical reasoning of first-year engineering students in scenarios specific to the engineering profession.
2. Develop several game-based learning interventions focused on ethical reasoning for first year engineering students.
3. Determine how game-based vs. non game-based approaches affect students' ethical reasoning in engineering.

To-date, the project has focused on two parallel goals: preliminary evaluations of students' baseline thinking regarding ethical and moral reasoning (Objective 1) and development and refinement of the game interventions to be used in the studies (Objective 2).

Objective 1 - Evaluations of Student Ethical Reasoning: Prior to exposure to any ethical instruction, students at participating institutions completed surveys designed to quantitatively measure their ethical reasoning, both generally and within an engineering context. For general moral and ethical reasoning, students took the Defining Issues Test (DIT-2) [10]. For engineering-specific ethical reasoning, students took the Engineering Ethics Research Instrument (EERI), designed by researchers at Purdue University. [11]

In the Spring 2022 and Spring 2023 semesters, both first year and senior students at a subset of the participating institutions took the EERI instrument. For first-year students this was the continuation of baseline evaluation of ethical reasoning. For seniors, this was to compare to the same data taken in the first year to evaluate any longer-term longitudinal changes in ethical reasoning that occurred over the course of the entire collegiate experience. Additionally, a comparison of data obtained from the EERI and data obtained from the student playthrough of the Mars: An Ethical Adventure game were compared both qualitatively and quantitatively, with results presented at the 2022 FIE Conference in Uppsala, Sweden. [12]

Objective 2 - Develop Game-Based Learning Interventions Focused on Ethical Reasoning and Decision Making: Three different game-based interventions have been designed and refined since the start of the grant period. As this time period coincided with the start of the COVID-19

pandemic and most if not all of the instruction at the participating institutions was moved to an online environment; significant work was done to adapt the gameplay and deployment of all of the games to reflect this reality. Long term, the online modality option will allow for greater flexibility and choice in the dissemination of the game materials to the larger community. A short description of each game can be read below.

1. **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 experiences of the research team. 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, wherever they may be.

2. **Toxic Workplaces:** Toxic Workplaces is a scenario-based card game which requires the players to evaluate an engineering ethics dilemma, and then collaboratively evaluate potential responses to that scenario. Different responses are given on individual cards, and the goal of the players is to collectively negotiate the ordering of the responses, from least likely to be chosen to most likely. Once the players have ordered all the responses for a scenario, the cards are flipped over to reveal the actual percentages, and scoring occurs, with higher scores given when the player-chosen ordering most closely matches the actual ordering by percentage. 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.

3. **Choose Your Own Adventure (CYOA): Mars - An Ethical Expedition:** As compared to the other two games, the CYOA game unfolds over a series of weeks in a narrative arc. Each week students are presented with an ethical dilemma contextualized within the narrative of the students being a new engineering team 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). In Winter 2022, the Mars game was ported to a voice-acted podcast-style delivery, and in Winter 2023, has been ported to the Godot platform. (https://godotoengine.org)

All of these versions of the games were used during the Spring 2021, Spring 2022, Spring 2023, and Spring 2024 semesters in various combinations at the participating institutions.

Lessons Learned to Date

We are currently in the 4th and final year of the grant. In the past year, we have focused on developing a deeper understanding of the challenges in assessing changes in student ethical reasoning, as well as continuing development and refinement of the game-based interventions, with a focus on the Mars: An Ethical Expedition game. Below is a summary of our findings from the past year, as well as a discussion about the next steps in the use of playful learning for both teaching and assessment of ethical skills.

The Challenges in Evaluating Student Ethical Reasoning: The assessment of ethical reasoning is of paramount importance in engineering education. As future engineers are poised to face increasingly complex ethical dilemmas, amplified by rapid technological advancements, it becomes essential to ensure they are well-equipped with robust ethical reasoning skills. In response to this need, various assessment tools have been developed to evaluate the ethical reasoning abilities of engineering students. One such tool is the Engineering Ethics Reasoning Instrument (EERI) [11]. The EERI uses this framework to evaluate where students stand in their moral development and how they apply these principles to real-world engineering scenarios. Typically, the evaluation of data from the EERI concentrates on two key metrics: the P score and the N2 score. There is a notable gap in current research using the EERI. Most previous studies employing the EERI have been limited in scope - either involving small sample sizes, lacking a longitudinal perspective, or focusing primarily on graduate students rather than undergraduates [13,14]. In the final year of the grant, we looked to conduct a larger-scale, longitudinal analysis specifically targeting undergraduate engineering students.

In our previous research, we found that students' ethical reasoning abilities, as measured by the EERI, exhibit minimal change over the course of a semester. This raises questions about whether our current ethics curriculum is effectively fostering moral reasoning development or if the EERI might be insufficient in capturing the subtleties of students' situated understanding and ability to reason and act ethically in authentic scenarios. In response to these findings, we broadened the scope of our study to encompass the full duration of students' undergraduate careers. This expansion was driven by the hypothesis that a single semester of ethics education within the curriculum might not be sufficient to effect significant changes in students' ethical reasoning. However, we speculated that over the entirety of their undergraduate experience, a more notable change in their ethical reasoning might become evident. The details of the study can be found in "The Challenges of Assessing In-The-Moment Ethical Decision Making" [15], which was submitted to the 2024 ASEE Annual Conference and Exposition.

In short, we found no detectable growth in students' ethical reasoning across a four-year undergraduate engineering program, as measured by the EERI. The changes in scores suggest a more nuanced shift in ethical reasoning. One conjecture is a reduction in naivety commonly experienced by students during their undergraduate years. As students progress through college,

there is a decrease in adherence to idealistic, universal principles. The major takeaway from this study (and our research as a whole), is that current methods of assessing ethics may not be sufficient in capturing students' ethical development. This emphasizes the need for a more dynamic, contextually rich, and potentially interactive approach to assess engineering ethics.

Collective vs Individual Ethical Decision Making: As the complexity of ethical challenges in engineering escalates - consider the dilemmas in programming self-driving cars or decisions that affect personal relationships - the need for more immersive and contextualized educational approaches becomes apparent. This is where the concept of situated cognition becomes invaluable. Situated cognition theory posits that knowledge is inextricably linked to the context in which it is used, suggesting that learning occurs most effectively when it is part of an activity, culture, or context [16,17]. It emphasizes that cognition cannot be separated from the environment in which it occurs, making it a strong theoretical basis for engineering ethics education [16,17]. The application of situated cognition in learning contexts, especially through the use of narrative and role-playing games, represents a shift from traditional methods of ethics education to more dynamic, context-rich learning experiences. Our game, Mars: An Ethical Expedition (Mars) exemplifies this approach. As an interactive, narrative game, it situates students in the role of a head engineer on Mars, challenging them with high-stakes decision-making scenarios that closely mirror real-world engineering dilemmas. This game demonstrates how educational games can foster a deeper and more authentic engagement with ethical decision-making. The primary objective of Mars is to enrich ethical decision-making skills among undergraduate engineering students. By immersing players in the role of a Mars settlement engineer, the game contextualizes ethical dilemmas within a realistic engineering project. Players are not merely presented with abstract right or wrong choices; instead, they must employ personal reasoning and context-dependent justifications in their decision-making process. The game's impact is evident in its influence on student behavior. In previous Mars iterations, students displayed a tendency to increasingly deviate from established engineering guidelines as they progressed through the game. This trend, peaking in scenarios like deciding the fate of a pregnant subordinate against settlement rules, suggests increased context can influence students' ethical decision-making. The details of this study can be found in "Empowering Ethical Decision-Making: Collective vs Individual Decision-Making in an Engineering Narrative Game" [18], which was submitted to the 2024 ASEE Annual Conference and Exposition.

The preliminary findings from this study offer valuable insights into the ethical decision-making processes of undergraduate engineering students. The game, designed around the concept of situated cognition, places students in realistic, high-stakes scenarios, compelling them to navigate complex ethical dilemmas. The data collected reveals significant differences in decision-making patterns between individual and whole class play modes, highlighting the influence of social dynamics and individual reasoning on ethical choices. The game's realistic scenarios and the requirement for immediate decision-making foster a deeper understanding and internalization of ethical principles compared to traditional, more abstract methods of ethics education.

Future Work – The Power of Play in Engineering Ethics Education

Playful learning offers unique affordances for the practical assessment of ethics learning outcomes. Current ethical assessments often place undue emphasis on the categorization of knowledge and skills, while not sufficiently addressing the process through which students navigate and act on ethical dilemmas. This, we posit, is an area that needs redefining, given that ethical decision-making is rarely a linear process with single objective "right" answers and often involves iterative reasoning and interactive engagement with the problem. We propose that assessments ought to focus on students' decision-making process and the decision-situation dynamics, and their emergent perception of the problem and potential actions as they gain more situational awareness. This practical, process-focused active learning assessment might help to illuminate the student's first-person, action-oriented ethical reasoning, and provide instructors with a deeper understanding of their decision-making abilities. Our goal is not to identify students' 'right' answers, but to appreciate the spectrum of ethical considerations students engage with and the nuances of their deliberation within the dynamics of realistic ethical decisions and actions.

In contrast to traditional engineering ethics assessments, assessments in a playful learning context can be designed to capture the interactional dynamics of ethical thinking in-the-moment, and as such these assessments may offer an expanded picture of how a student may behave in real situation involving ethical engineering decisions. The existing paradigm of ethics education assessment often falls short in its capacity to truly capture the complexity of in-vivo ethical decision-making. It is predominantly centered on static linear cognitive measurements rather than nonlinear dynamics associated with complex realistic ethical situations and fails to engage students in interactive actions other than making singular decisions and justification. We assert that playful learning environments can afford the assessment of ethical decision making as a first-person interaction and engagement with dynamic information in the world.

Looking ahead, future research directions will focus on further refining Mars to enhance its educational impact. This includes the integration of more open-ended response questions and the development of advanced text analytics algorithms to efficiently analyze qualitative data, as well as the development of different game versions with varying contextual depths to validate the importance of context in ethical decision-making. By evolving Mars and its assessment methods, we aim to equip future engineers with a robust ethical framework, prepared to navigate the multifaceted moral challenges of their profession.

We acknowledge the introduction of game-based assessment models (like Mars) likely will raise more questions than it answers - a reality that is not a flaw but a strength by the line of inquiry it introduces. Challenging the status quo and redefining constructs may open a plethora of new research opportunities and should prompt a deeper, more critical engagement with the teaching and learning of engineering ethics.

Acknowledgements

This research is being funded by the National Science Foundation, “Collaborative Research: Learning Engineering Ethics Through High-Impact Collaborative and Competitive Scenarios” (IUSE – 2211320 and 1934707).

References

[1] S. Streiner, D. Burkey, M. Young, R. Cimino, & J. Pascal, “Engineering Ethics Through High-Impact Collaborative/Competitive Scenarios (E-ETHICCS)." ASEE Annual Conference and Exposition, Long Beach, CA, July 2021

[2] P. Patel, “Engineers, Ethics, and the VW Scandal,” IEEE Spectrum, 25 Sept. 2015. [Online]. Available: http://spectrum.ieee.org/cars-that-think/at-work/education/vw-scandal-shocking-but-not-surprising-ethicists-say. [Accessed Apr. 11, 2019].

[3] M. Hart, “The Ethical Lessons of Deepwater,” ASME.org, March 2011. [Online]. Available: https://www.asme.org/engineering-topics/articles/engineering-ethics/the-ethical-lessons-of-deepwater. [Accessed Apr. 11, 2019].

[4] R.P. Boisjoly, E.F. Curtis, & E. Mellican, “Roger Boisjoly and the Challenger Disaster: The Ethical Dimensions,” Journal of Business Ethics, vol. 8, no. 4, pp. 217-230, 1989.

[5] H.W. Gehman, Jr., J.L. Barry, D.W. Deal, J.N. Hallock, K.W. Hess, G.S. Hubbard, J.M. Logsdon, D.D. Osheroff, S.K. Ride, R.E. Tetrault, S.A. Turcotte, S.B. Wallace, and S.E. Widnall, “Columbia Accident Investigation Report, Volume I,” NASA, Aug. 26 2003. Available:http://www.nasa.gov/columbia/home/CAIB_Vol1.html.

[6] S. Bates, “Flint water crisis: For young engineers, a lesson on the importance of listening,” NSF.gov, 23 March 2016. [Online]. Available: http://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=138060&WT.mc_id=USNSF_1. [Accessed Apr. 11, 2019].

[7] K. Samuelson, “Companies That Built Collapsed FIU Bridge Had Been Fined for Safety Violations,” time.com, 16 Mar. 2018. [Online]. Available: http://time.com/5203126/fiu-bridge-collapse-safety-violations/. [Accessed Apr. 11, 2019].

[8] M. Peterson, “The Ethical Failures Behind the Boeing Disasters,” Blog of the APA, 8 Apr. 2019. [Online]. Available: https://blog.apaonline.org/2019/04/08/the-ethical-failures-behind-the-boeing-disasters/. [Accessed Apr. 11, 2019].

[9] “Engineering The Future, 2008 Annual Report”, Engineering The Future, 2008 Annual Report, National Academy of Engineering, [Online]. Available: https://www.nae.edu/File.aspx?id=43355. [Accessed Apr. 11, 2019].

[10] Rest, J., Narvaez, D., Bebeau, M., & Thoma, S. (1999). A neo-Kohlbergian approach: The DIT and schema theory. Educational Psychology Review, 11(4), 291-324.

[11] Zhu, Q., & Zoltowski, C. B., & Feister, M. K., & Buzzanell, P. M., & Oakes, W. C., & Mead, A. D. (2014, June), The Development of an Instrument for Assessing Individual Ethical Decision Making in Project-based Design Teams: Integrating Quantitative and Qualitative Methods. Paper presented at 2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana. 10.18260/1-2—23130

[12] D. Burkey, R. Cimino, M. Young, K. Dahm, & S. Streiner (2022, October). It’s All Relative: Examining Student Ethical Decision Making in a Narrative Game-Based Ethical Intervention. In *2022 IEEE Frontiers in Education Conference (FIE)* (pp. 1-6). IEEE.

[13] L. G. Kisselburgh, J. L. Hess, C. B. Zoltowski, J. Beever, and A. O. Brightman, “Assessing a Scaffolded, Interactive, and Reflective Analysis Framework for Developing Ethical Reasoning in Engineering Students,” ASEE Annual Conference and Exposition, Jul. 2016, doi: 10.18260/p.26288.

[14] J. L. Hess, J. Beever, C. B. Zoltowski, L. G. Kisselburgh, and A. O. Brightman, “Enhancing engineering students’ ethical reasoning: Situating reflexive principlism within the SIRA framework,” Journal of Engineering Education, vol. 108, no. 1, pp. 82–102, Jan. 2019, doi: 10.1002/jee.20249.

[15] Wagner, T., Burkey, D., Young, M., “The Challenges of Assessing In-The-Moment Ethical Decision-Making,” submitted to the ASEE Annual Conference and Exposition, June 2024, Portland, Oregon.

[16] J.S. Brown, A. Collins, and P. Duguid, “Situated cognition and the culture of learning.” Educational Researcher, 1989, vol. 18, no. 1, pp. 32-42.

[17] J. Lave and E. Wenger, Situated learning: Legitimate peripheral participation. Cambridge, UK: Cambridge University Press, 1991.

[18] Wagner, T., Young, M., Burkey, D., Cimino, R., Streiner, S., Dahm, K.., “Empowering Ethical Decision-Making: Collective vs. Individual Decision-Making in an Engineering Narrative Game,” submitted to the ASEE Annual Conference and Exposition, June 2024, Portland, Oregon.