

UC San Diego

UC San Diego Previously Published Works

Title

Implementing a Praxis of Change: A Comparative Case Study on Interactive Methodologies and the Instruction of Engineering Ethics

Permalink

<https://escholarship.org/uc/item/55m3s06t>

Journal

2025 IEEE Frontiers in Education Conference (FIE), 00

Authors

Gerardo, Hortense
Marinoni, Alessandro
De Callafon, Raymond

Publication Date

2025-11-05

DOI

10.1109/fie63693.2025.11328249

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed

Implementing a Praxis of Change: A Comparative Case Study on Interactive Methodologies and the Instruction of Engineering Ethics

Hortense Gerardo
*Anthropology, Performance, and Technology
(APT) Program
UC San Diego
La Jolla, California, US
hgerardo@ucsd.edu*

Alessandro Marinoni
*Mechanical and Aerospace Engineering
UC San Diego
La Jolla, California, US
amarinoni@ucsd.edu*

Raymond de Callafon
*Mechanical and Aerospace Engineering
UC San Diego
La Jolla, California, US
callafon@ucsd.edu*

Abstract—This Work-in-Progress paper introduces an experiential, game-based intervention for teaching engineering ethics to upper-level undergraduates in Mechanical and Aerospace Engineering (MAE). Traditional ethics instruction often emphasizes compliance and regulatory frameworks, which may inadequately prepare students for real-world dilemmas characterized by incomplete information, ambiguous trade-offs, and the need for trust among interdisciplinary teams. To address this gap, we developed a role-playing card game grounded in experiential learning theory, socio-technical systems thinking, and moral development frameworks.

Students assume roles as Managers or Engineers within fictional companies competing for a client's sponsorship. Managers are briefed on project priorities (e.g., cost, sustainability), while Engineers possess information about available resources. This asymmetrical distribution of knowledge simulates real-world engineering environments and requires students to iteratively negotiate and revise design proposals under ethical and practical constraints. An "Ethics Points" system incentivizes decisions that prioritize stakeholder accountability, and final scoring rewards trustworthiness over profit-maximization.

The educational setting includes mixed-methods assessment: post-game surveys to evaluate changes in ethical sensitivity and moral reasoning; qualitative reflection essays; and observational analysis of team dynamics during gameplay. Preliminary results indicate heightened engagement, improved ethical awareness, and stronger collaboration—findings that align with existing literature on the benefits of simulation- and game-based learning in engineering ethics.

This intervention aims to humanize STEM instruction by embedding ethical reasoning into collaborative, interactive activities. The findings offer implications for broader integration of trust-centered pedagogies in interdisciplinary engineering courses and professional training contexts.

Keywords— *Ethics, Engineering Education, Experiential Learning, Role-Playing, Trust in Decision-Making*

I. INTRODUCTION

Engineering ethics education is pivotal in preparing students to navigate complex moral landscapes inherent in professional

practice. Traditional instructional methods, often centered around compliance and case study analyses, may not sufficiently equip students with the skills to handle real-world ethical dilemmas characterized by uncertainty and competing interests [1], [2]. This paper presents a Work-in-Progress study introducing a game-based experiential learning approach aimed at enhancing ethical decision-making and trust-building among engineering students.

II. BACKGROUND AND MOTIVATION

Previous implementations by Gerardo and de Callafon demonstrated the efficacy of interactive presentations and student-created case study videos in ethics education [3]. Building upon this foundation, the current study integrates a role-playing card game to simulate real-world engineering scenarios. The theoretical underpinnings draw from Kolb's experiential learning theory [4], which emphasizes learning through experience, and Rest's model of moral development [5], highlighting the progression of ethical reasoning.

III. METHODOLOGY

The designed card game assigns students to roles as Managers or Engineers within competing companies. Managers are informed of client priorities but lack knowledge of resource values, whereas Engineers understand resource constraints but are unaware of project specifications. This asymmetry reflects real-world engineering challenges where decisions must be made with incomplete information. The game incorporates an "Ethics Points" system, allowing players to enhance proposals ethically, with Managers having the authority to accept or reject proposals, prompting iterative refinement.

This pedagogical intervention centers around a physical, role-based card game designed to simulate ethical decision-making in engineering practice. The game is currently deployed in non-digital, physical form to allow for hands-on iteration of its mechanics based on classroom observations and student feedback. To date, it has been play tested in three upper-division undergraduate courses in the Mechanical and Aerospace Engineering (MAE) department at the University of California, San Diego, each consisting of students majoring in Mechanical or Aerospace Engineering.

The game draws on socio-technical systems principles and experiential learning theory to model the real-world challenge of navigating incomplete information and conflicting stakeholder interests. Students are divided into teams composed of two Managers and two Engineers, working within fictional companies to compete for a client contract.

The structure of the game centers around epistemic asymmetry:

- **Managers** are given a **Client Card** with the client's top three project priorities (e.g., sustainability, cost-efficiency, safety).
- **Engineers** receive a hand of **six Resource Cards**, each describing possible project materials or strategies, along with associated costs, environmental impacts, safety trade-offs, and development timelines.

This epistemic asymmetry replicates real-world engineering scenarios where decision-making occurs under partial information and distributed expertise, reflecting principles described in experiential and socio-technical learning literature [6][7].

Teams engage in up to three rounds of proposal development. Engineers select three Resource Cards, optionally spending up to two *Ethics Points* per round to upgrade or swap cards ethically. Managers evaluate summary proposals (without full resource data) and can accept or reject them. Rejected proposals are revised, mirroring iterative professional engineering processes. Final scoring combines alignment with client priorities and unspent Ethics Points, reinforcing that ethical conduct yields long-term value and trust [8][4].

Observations from playtesting suggest the tangible, face-to-face gameplay deepens student engagement and fosters interpersonal trust—consistent with findings on role-play-based ethics education in the engineering context [9][10]. Ongoing assessment uses mixed methods: post-game surveys of ethical sensitivity and moral reasoning, reflective essays, and qualitative analysis of group dynamics.

Together, teams must negotiate and submit project proposals that address the client's goals while working within ethical and technical constraints. The game's central innovation is an Ethics Points system, which students may spend to ethically upgrade or revise aspects of their proposal. Critically, Ethics Points retained at the end of the game contribute to the final score, reinforcing the idea that ethical integrity has long-term value.

Student-Facing Rules

1. Each team has **2 Managers** and **2 Engineers**.
2. **Managers** are given the **Client Card**, listing the client's top 3 priorities.
3. **Engineers** are given **6 Resource Cards** with variables such as cost, labor impact, development speed, and environmental risk.
4. **Engineers** build a proposal using 3 of their 6 Resource Cards.

5. Engineers may spend up to 2 Ethics Points per round to upgrade or swap Resource Cards.

6. **Managers evaluate the proposal** (they do not see detailed resource data).

7. Managers may **accept or reject** the proposal. If rejected, Engineers must revise.

8. Teams have **3 rounds** to submit a final proposal.

9. Final scoring is based on:

- How well the proposal aligns with the client's stated priorities
- The number of Ethics Points **retained** by the end of the game



Fig. 1. Game Flow Chart for Ethics Role-Playing Card Game developed for Undergraduate Majors in Aerospace and Mechanical Engineering.

IV. EVALUATION AND PRELIMINARY FINDINGS

Assessment methods include pre- and post-game surveys evaluating ethical reasoning, student reflections, and instructor observations. Preliminary results indicate increased student engagement, heightened ethical awareness, and improved

teamwork skills. These findings align with existing literature on the benefits of simulation-based learning in engineering ethics education [11], [12].

This game structure not only simulates authentic engineering dilemmas involving distributed expertise and unclear boundaries of responsibility, but it also provides a space where trust and ethical leadership must be developed organically within teams. Observations from the classroom suggest that the physical nature of the game (e.g., tangible cards, face-to-face roleplay) enhances student immersion and group dynamics. Ongoing refinement of the game mechanics is informed by iterative cycles of student feedback, instructor observation, and classroom data collection.

Assessment incorporated mixed methods including pre- and post-game surveys to measure changes in ethical sensitivity and moral reasoning, student reflective essays, and instructor observations of team dynamics. Preliminary findings demonstrate increased student engagement, enhanced ethical awareness, and improved teamwork skills, consistent with literature highlighting the effectiveness of simulation-based learning in ethics education [13][14].

The game's face-to-face, tangible **format** further promotes immersion and social interaction in ways that align with evidence supporting role-play and active learning in engineering ethics contexts [15][16]. Instructors reported that the physical exchange of cards and direct negotiation promoted trust as a necessary social mechanism for collaboration—concepts well-documented in studies on role-play pedagogy and trust-building in instruction [15].

Feedback from students emphasized that the iterative nature of proposal revisions and acceptance-based round progression simulatively modeled professional engineering workflows, reinforcing reflective practice. This method of iterative, decision-point experiences mirrors best practices in simulation-based education where learners benefit from **debriefing and reiteration loops** [11].

Ongoing refinement of the game mechanics is guided by an iterative design-based research approach, with cycles of playtesting, student feedback, and observational analysis. This aligns with established engineering education research methods that emphasize formative evaluation, trust-building, and team performance improvement through simulation-like interventions [17][12].

V. COMPARATIVE ANALYSIS OF VIDEO CASE STUDY VERSUS INTERACTIVE CARD GAME

To understand the pedagogical efficacy of interactive ethics instruction, a comparative analysis was conducted between two experiential learning interventions: (1) a student-created video case study project and (2) the newly introduced role-playing card game. Both activities were implemented in upper-level Mechanical and Aerospace Engineering (MAE) courses and aimed to immerse students in ethical dilemmas relevant to real-world engineering practice. While both methods drew on active

learning frameworks and situated moral reasoning, they differ in structure, interactivity, and learner engagement.

A. Student Interactivity

The video assignment required students to collaboratively script, film, and present a case study depicting an ethical engineering scenario. This project fostered creativity and teamwork but allowed for a relatively asynchronous division of labor. In contrast, the card game necessitated synchronous, real-time decision-making under time constraints and knowledge asymmetries. Students engaged dynamically through iterative negotiation and debate, which promoted spontaneous ethical reasoning.

B. Relevance to Engineering Practice

While the video project enabled students to simulate scenarios derived from real-life engineering dilemmas, the authenticity was filtered through pre-production planning and dramatic interpretation. The card game, however, imposed situational constraints analogous to those found in professional practice—such as trade-offs between sustainability, cost, and speed, and decision-making amid incomplete information. Students reported that the game “felt like being on an actual project team,” suggesting a higher perceived alignment with workplace dynamics in engineering fields.

B-5. The subject matter has significant relevance and usefulness to my education
82 responses

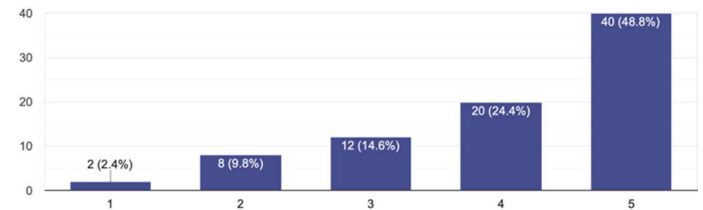


Fig. 2. MAE 171A Student evaluation of course effectiveness.

B-5. The subject matter has significant relevance and usefulness to my education
81 responses

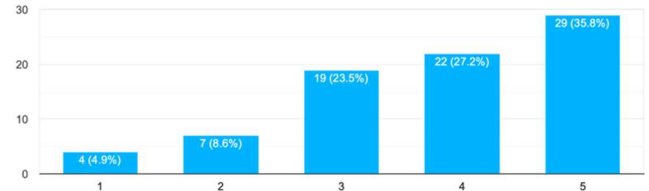


Fig. 3. MAE 175A Student evaluation of course effectiveness.

C. Student Enjoyment and Engagement

Student feedback was overwhelmingly positive for both activities. One student wrote, “The most useful was the video-making assignment. This forced me to look up the topics and

get acquainted with different moral dilemmas.” Another wrote, “We did the interactive game. I think the most useful part was the discussion my group had after the game, which really talked about how ethics is not as black and white or simple as it sometimes may seem.” In general, the interactive card game seemed to invoke more in-depth discussion among the groups who chose that option, as opposed to the making of the video, as conveyed by this student, “I think that the meaningful discussion and internal decision making that occurred within gameplay is the best way to experience these ethical conundrums (more so than producing a scripted video in my opinion), so I would advocate for the requirements for the game to focus less on grabbing/holding attention and videography, and instead focus players on the experience of the game itself. The playful yet high-stakes format of the game appears to create a unique learning atmosphere where emotional investment enhances cognitive engagement, a phenomenon also supported in the literature on gamified learning.

B-4. The ethics module was structured to facilitate discussion and participant contribution
82 responses

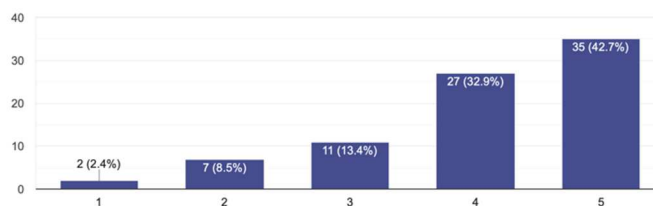


Fig. 4. MAE 171A Student evaluation of course effectiveness.

B-4. The ethics module was structured to facilitate discussion and participant contribution
81 responses

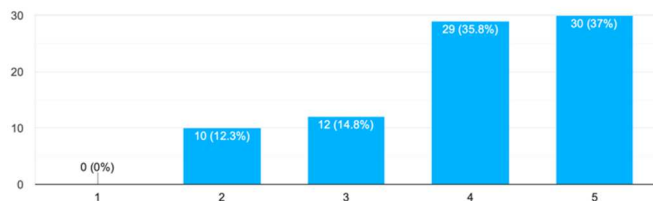


Fig. 5. MAE 175A Student evaluation of course effectiveness.

This comparative analysis reinforces the value of integrating diverse, interactive pedagogies in engineering ethics education. While video projects offer opportunities for reflective storytelling and creative expression, real-time role-playing simulations may better cultivate decision-making under pressure and deepen students’ appreciation of ethical complexity.

VI. IMPLICATIONS AND FUTURE WORK

The integration of game-based learning in engineering ethics education shows promise in fostering trust and ethical decision-making. More feedback from students about the mechanics of the gameplay will help to fine-tune the ethical lessons to be learned from this form of interactive learning. Future research will explore the scalability of this approach across various

engineering disciplines and its applicability in professional training settings.

VII. CONCLUSION

This Work-in-Progress paper presents a novel, role-based, game-driven pedagogical model for ethics instruction in engineering education. By embedding ethical dilemmas, asymmetrical knowledge, and iterative proposal evaluation into a competitive team-based card game, the intervention simulates the complex social and technical dynamics of real-world engineering practice. The tangible, analog format of the game—paired with asymmetric roles (Managers and Engineers)—encourages students to engage in trust-building, ethical negotiation, and collaborative decision-making under constrained and uncertain conditions.

Preliminary findings from three upper-level Mechanical and Aerospace Engineering courses suggest the game format fosters increased engagement, greater ethical awareness, and enhanced teamwork skills. These early results are consistent with prior scholarship on the value of simulation-based learning and role-play in developing ethical reasoning and professional competencies.

This intervention contributes to the growing body of work that seeks to humanize STEM curricula by grounding ethics education in experiential, interactive, and socially embedded contexts. Unlike static case-based approaches, this model provides an opportunity for students to *practice* ethical leadership rather than merely analyze it.

Future work will include refining the game mechanics based on iterative classroom feedback, extending the evaluation through longitudinal assessment of retained ethical reasoning, and exploring adaptation for interdisciplinary cohorts and professional development contexts. By highlighting trust as both a condition and an outcome of ethical collaboration, this approach offers a scalable framework for teaching ethics as a lived, relational practice within engineering education.

REFERENCES

- [1] J. Herkert, “Engineering Ethics Education in the USA: Content, Pedagogy and Curriculum,” *Eur. J. Eng. Educ.*, vol. 25, no. 4, pp. 303–313, 2000.
- [2] M. Davis, *Engineering Ethics: Real-World Case Studies*. New York, NY, USA: Oxford Univ. Press, 2006.
- [3] H. Gerardo and J. de Callafon, “Interactive Ethical Scenarios in Systems Engineering Education: A Case-Based Approach,” *Proc. ASEE Annu. Conf. Expo.*, Minneapolis, MN, USA, 2022.
- [4] D. A. Kolb, *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ, USA: Prentice Hall, 1984.
- [5] J. R. Rest, *Moral Development: Advances in Research and Theory*. New York, NY, USA: Praeger, 1986. G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” *Phil. Trans. Roy. Soc. London*, vol. A247, pp. 529–551, April 1955.
- [6] K. Martin et al., “The role of role-play in student awareness of the social dimension of the engineering profession,” *Eur. J. Eng. Educ.*, year unknown. ASEE Peer +3arXiv+3PhilPapers+3TU/e Research Portal.
- [7] M.F. Young, L. Bassett, D.D. Burkey, S.C. Streiner, J.B. Reed. *Let’s Play! Gamifying Engineering Ethics Education Through the Development of Competitive and Collaborative Activities*. Paper presented at 2021

- ASEE Virtual Annual Conference Content Access, Virtual Conference. <https://peer.asee.org/37452> Rowan Digital Works+1National Science Foundation+1
- [8] J. A. Kolb, *Experiential Learning: Experience as the Source of Learning and Development*, Prentice Hall, 1984. SpringerLink+15Wikipedia+15ASEE Peer +15.
 - [9] R. Goerge (PhilPapers), *Roleplaying Game-Based Engineering Ethics Education*, ResearchGate+11PhilPapers+11ASEE Peer +11
 - [10] S. W. Lau, T. P.L Tan, & S.K. Goh, (2012) *Teaching engineering ethics using BLOCKS game*. Science and Engineering Ethics. Volume 19, pages 1257-1373.
 - [11] F. Lateef. *Simulation-based learning: Just like the real thing*. Journal of Emergency Trauma Shock. 2010 Oct-Dec;3(4):348–352. doi: 10.4103/0974-2700.70743.
 - [12] Martin, D. A. (2024). *Teaching methods in engineering ethics education*. In S. Chance, T. Børsen, D. A. Martin.
 - [13] M. Xenos and V. Velli, *A Serious Game for Introducing Software Engineering Ethics to University Students*, ICL2018, 21st International Conference on Interactive Collaborative Learning, pp. 263-274, Kos, Greece, 25-28 September 2018 *arXiv preprint arXiv:1903.01333*, 2019.
 - [14] A. G. Gordillo and D. López-Fernández, *Are Educational Escape Rooms More Effective Than Traditional Lectures for Teaching Software Engineering? A Randomized Controlled Trial*. *IEEE Transactions on Education*, 2024 *arXiv preprint arXiv:2407.12355*, 2024.
 - [15] B. J. Brummel, C. K. Gunsalus, K. L. Anderson, and M. C. Loui, “Development of role-play scenarios for teaching responsible conduct of research,” *Science and Engineering Ethics*, vol. 16, no. 3, pp. 573–589, 2010.
 - [16] N. Doorn and J. O. Kroesen, *Using and developing role plays in teaching aimed at preparing for social responsibility*. *Science and Engineering Ethics*, vol. 19, no. 4, pp. 1513–1536, 2013.
 - [17] *Development and evaluation of expert witness role-play for engineering ethics education*, ASEE Annual Conference, peer-reviewed