

Board 371: Research Initiation: Expanding the Boundaries of Ethical Reasoning and Professional Responsibility in Engineering Education Through Critical Narrative

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Introduction

This paper provides a brief summary and overview of a research project completed through NSF Grant No. 2024973[1] between December 2020 and December 2023. The objective of the project was to evaluate the efficacy of critical narrative as a pedagogical tool for helping engineering students engage with the broader impacts and professional responsibilities associated with engineering work. Motivation for the project was driven by a recognition within the research team that traditional engineering case studies often fail to engage students in critical thinking beyond the boundaries of the information provided in the specific case. Consistent with findings by Martin et al. (2021)[2], traditional case studies are also limited to “decision-making in professional contexts and less on power relations, equity and the broader societal mission of engineering.” As a novel pedagogical tool in engineering education, we define critical narratives as structured, place-based narratives about complex engineering and ethical dilemmas without clear solutions. These narratives emphasize the significance of the physical environment and the unfolding of experiences over time. Inspired by critical pedagogy and theory, critical narratives aim to engage students with social realities and power dynamics, promoting critical thinking about moral judgment, fairness, and justice. Unlike traditional case studies or ethics modules focused on codes of ethics, critical narratives are designed to enhance problem-solving skills transferable to real-world scenarios involving various stakeholders.

Intervention

The intervention that was evaluated in this study was built around three critical narratives that were obtained from publicly available episodes of the NPR programs *Radiolab* and *This American Life*. Importantly, the critical narratives we selected don't present the issues being explored as having one right answer. Rather, the narrators offer multiple perspectives, along with a variety of details, research, and the hallmarks of a podcast: authenticity, fast pace, sound bites, etc. [3]. The first narrative, *Rhino Hunter* [4], discusses current practices that are intended to preserve endangered species by selling permits to hunters to kill them. The second narrative, *Hungry, Hungry People* [5], describes a plan in the early 20th century to address a food shortage in the US by importing hippopotamuses to the bayous of Louisiana. The final narrative, *How do you solve a problem like Fritz Haber?* [6], discusses the German, Nobel-Prize-winning chemist and his discovery of a process to convert atmospheric nitrogen into liquid-ammonia fertilizer. Additional details regarding the narratives can be found in Brown et al. [7].

The study was completed at Embry-Riddle Aeronautical University in Daytona Beach, Florida, and included as participants senior students completing their capstone design projects in mechanical and aerospace engineering. The first phase of the project began with a pilot study that sought to evaluate whether students were connecting with the narratives and, most importantly, able to draw connections between the narratives and engineering work. For each of the three narratives, students were required to: (1) listen to the narrative, (2) respond to five focus questions, (3) engage with the responses of at least two of their peers, and (4) reflect on the overall experience of discussing the narrative with their peers. The focus questions used in the pilot study were as follows:

1. What are the main ethical questions at play in this particular story?
2. Which actions made by the story's characters struck you as totally "unethical"?

3. Which actions by the different characters raise ethical questions that are not entirely clear cut? In other words, which actions might be considered to fall within a so-called "grey area"?
4. Does this story raise any issues or concerns that might be particularly relevant to engineers?
5. What are some of the issues raised by this story that might affect one's decision making as a common citizen?

Reflection question:

1. In a separate reply, describe how the responses of your colleagues and subsequent dialogue may have changed your perspective on the issues raised by this critical narrative.

Qualitative analysis of student responses from the pilot study confirmed that engagement with critical narratives does help some students make connections between their profession and the broader impacts of engineering work. Researchers noted evidence of metacognition, the ability to apply and synthesize information, practice dynamic learning, identify clear aspects of professional ethics, and see "grey" areas of ethical or moral dilemmas. Students also demonstrated an ability to weigh potential harm and consider the role of passion in relation to their ethical responsibility as an engineer.

After validating the general efficacy of the narratives, the main study included a study group (SG) that completed the exercise for three critical narratives and a comparison group (CG) who did not. Four sections of preliminary capstone design were identified for SG and four different sections were identified for CG. Near the end of the semester, both the SG and CG completed a group discussion activity in which they were required to provide responses to the following focus questions regarding their group's capstone design project:

1. Describe any ethical dilemmas you identified while working on your senior design project.
2. How did you respond to or address those ethical dilemmas in your project? Why? If you did not respond to or address any identified ethical dilemma in your project, please share your rationale.
3. How did the ethical dilemmas raised in your project connect to society in general?
4. How do you perceive your responsibility to address these types of ethical dilemmas? As an engineer? As a member of society? Why?
5. Consider the effectiveness of pausing to consider the ethical dilemmas you may have encountered in your senior design project and the opportunity to discuss them with your peers. Did your perspective on any issues change? Did your peers notice anything you might not have? Was it effective to pause and consider the ethics in and around your design and discuss them as a group online?

Results

Student responses to the project-group discussion questions were analyzed according to specific criteria for four different variables: (I) identify broader impacts, (A) apply engineering solutions that address broader impacts, (P) perceived responsibility to address ethical issues in engineering work, and (R) the capacity to reflect and how their perceptions may have shifted through course of the discussion with their peers. Responses were evaluated using a rubric with a 5-point scale. An independent samples t-test was conducted to compare the means of two groups (CG and SG) on the four variables related to the project group discussions: Apply, Identify, Perception, and Reflection. For Identify, the mean for SG, 2.61, was significantly higher than CG, 2.27, $t(100.025) = 2.555$, $p = .012$, with a medium effect size (Cohen's $d = .340$). For Apply, the mean for SG (2.8) was higher than CG (2.53) but not found to be significant, $t(104.994) = 1.884$, $p = .062$, and with a small to medium effect size (Cohen's $d = .265$). For Perception, there was no significant difference between the means of the two groups (SG=2.81, CG=2.75), $t(97.599) = .476$, $p = .635$, with a small effect size (Cohen's $d = .059$). Somewhat unexpectedly, for Reflection, the mean for CG (3.39) was significantly higher than SG (2.89), $t(57.279) = -2.723$, $p = .009$, with a medium to large effect size (Cohen's $d = -.498$). Additional details and discussion are located in Brown et al. (2023)[8].

Conclusions

This study suggests that engaging with critical narratives can significantly improve engineering students' ability to recognize ethical dilemmas and consider the broader impacts of their work. These narratives, which focus on moral judgment, provoke strong reactions from students, which enhances their application of critical thinking in engineering contexts. Further research is needed to compare the effectiveness of critical narratives with traditional ethics case studies in engineering. A notable benefit of critical narratives is their accessibility, allowing students of any expertise level to understand complex ethical issues without prior specialized knowledge in engineering ethics.

Disclaimer

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