

**Expanding the Boundaries of Ethical Reasoning and Professional  
Responsibility in Engineering Education through Critical  
Narratives**

## Introduction

For employers, institutions of higher education, and organizations like ABET, critical thinking is an increasingly necessary skill for undergraduate engineering students. Critical thinking in an engineering context requires students to make informed decisions related to complex problems “involving wide-ranging or conflicting technical issues, having no obvious solution, addressing problems not encompassed by current standards and codes, involving diverse groups of stakeholders, including many component parts or sub-problems, involving multiple disciplines, or having significant consequences in a range of contexts” [1].

With two student outcomes (SO-2 and SO-4), ABET clearly connects critical thinking with a sense of student growth in the realm of ethics and professional responsibility:

- SO-2: an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- SO-4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

To satisfy ABET’s ambitious goal for undergraduates to do more than just solve problems provided to them by a professor, researchers developed and analyzed a pedagogical intervention: critical narratives. Critical narratives are place-based narratives about complex engineering and ethical dilemmas that do not have a singular solution. Rather, critical narratives encourage students to consider the complex interactions between social, environmental, and economic factors and help them articulate the basic tenets of ethics and professional responsibility.

The professionally diverse group of investigators—civil engineering professor, engineering education researcher, a Ph.D. in literature, and an educational leadership doctorate—are committed to developing students’ values around ethics and professional responsibility (see Appendix for Positionality Statement). This is an important first step in addressing professional formation. Engaging with critical narratives can help students better address issues of global significance related to overall community health and well-being, including sustainability and resiliency.

## Purpose

The following research questions serve as the starting point for a larger, multi-year NSF-funded study:

1. How might strategic integration and critical thinking concerning critical narrative enhance engineering students’ development of ethics and professional responsibility (E&PR)?
2. As a pedagogical tool, how effective is critical narrative in developing students’ ability to use critical thinking traits to identify, formulate, and solve complex engineering problems that incorporate the broader impacts outlined in ABET SO-2 and SO-4?

This larger study is planned as a quasi-experimental design using mixed methods data collection that includes comparison between EPRA survey data, responses to critical narratives, and students’ consideration of the broader impacts of engineering work in their senior design projects.

This current paper describes a pilot study implemented in Spring Term 2021 and focuses on the qualitative responses to three different critical narratives that served as an ethics module in senior capstone design courses (see Appendix for additional information on the critical narratives selected for this pilot study) . Qualitative results from this paper provide partial and preliminary answers to the research questions from the larger study.

## **Background Literature and Previous Research**

While widely accepted as a necessary skill, critical thinking (CT) descriptions and measurements have evolved. In the early 1900s, educational theorist John Dewey closely tied CT to reflective thinking: active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends [2]. Bloom et al. [3] developed systematic ways to gauge CT and divided learning into three domains: cognitive, affective, and psychomotor. Bloom et al.'s work includes the six-level taxonomy: knowledge, comprehension, application, analysis, synthesis, and evaluation. These levels of cognition are interdependent, with recognition that real learning is an interactive and iterative process. In *A Taxonomy for Teaching, Learning, and Assessment* [4], education theorists and psychologists revisited Bloom's cognitive domain, removed Bloom's "synthesis" level, and added "create" above evaluation [5]. These scholars also included separate taxonomies of the types of knowledge used in cognition: Factual Knowledge, Conceptual Knowledge, Procedural Knowledge, and Metacognitive Knowledge. This study uses the revised framework to gauge whether critical narratives can move students beyond lower-order thinking like recall and increase their metacognition.

Because the need to increase critical thinking is clear, engineering faculty have since implemented many strategies and interventions 6(see Ahern et al. 2019). Most interventions focus on getting students to solve given problems via assigning case studies [7], [8], [9]. Traditional case studies exploring ethics in engineering tend to isolate ethical issues into a format whereby they can be "solved" (often with reference to a code of ethics). Unfortunately, these interventions keep students from being able to even identify a problem on their own or, worse, incorrectly reinforce the notion of a singular, technical solution to complex problems. Since ABET's asks students to go beyond identifying ethical and professional responsibilities in case studies or quantitative true/false (T/F) assessments, this study uses critical narratives to get students to robustly engage in CT practices that connect ethical and professional responsibilities to a variety of contexts.

## **Site & Participation**

Embry-Riddle Aeronautical University is a mid-sized, private, historically White university in the southeast with four colleges on the residential campus; the College of Engineering is by far the largest. There is not a formal program for ethics training within the College, rather each major department encourages individual instructors to include ethics within individual courses. For the pilot study, convenience sampling was used. Researchers identified four senior faculty willing to participate.

Students were recruited from four capstone design courses. 54 students were enrolled in selected courses and 42 of those (78%) provided informed consent (IC). 34 students with IC contributed qualitative responses in discussion posts. Of those 34 students, demographic information was provided by 30 students. Students' self-identified demographic information included nine

females (F), 20 males (M), and one (1) preferred not to disclose. There were 21 White, 5 Asian, 2 Hispanic, and 2 Black students.

## Intervention

Because each senior design course in the pilot study had varying learning outcomes, researchers selected three critical narratives that indirectly tied to engineering work and practice, encouraging students to make the connections between engineering work in their chosen discipline and the ethical issues revealed in a given critical narrative. Each critical narrative was in podcast format. Below are publication information and short synopses of the three narratives in the order that we assigned them; see Appendix for more information about these narratives.

Table 1. Critical narratives used in pilot study

<b>The Rhino Hunter</b> [10]	Produced by RadioLab, 7 September 2015	Follows Corey Knowlton who paid \$350,000 for a hunting trip to Namibia to shoot and kill an endangered rhino in Namibia in 2014
<b>Act Three: “Hungry, Hungry, People”</b> [11]	from “Except For That One Thing,” produced by This American Life, 14 Feb. 2014	Explores a plan to fix food scarcity in the U.S. by importing hippopotamuses to Louisiana in the early 1900s
<b>How do you solve a problem like Fritz Haber?</b> <sup>12</sup>	From “The Bad Show,” produced by RadioLab, 9 January 2012	Weighs chemist Fritz Haber’s chemical engineering feats and war crimes

## Methods

The results presented in this paper are limited to a qualitative grounded theory (GT) approach to analyze Question 4 (Q4) and reflections. Researchers limited analysis to Q4 because it most directly required students to connect the narrative to the field of engineering. Researchers were also interested in student perceptions of the critical narratives and any perceived value of discussing critical narratives with peers. GT is appropriate when little is known about a phenomenon - with the aim being to produce or construct an explanatory theory that uncovers a process inherent to the substantive area of inquiry [13]. Using GT, researchers iteratively developed codes that met standard measures of reliability and validity via inter-rater reliability coding. The researchers employed Focused Coding to synthesize and explain larger segments of data [14] which resulted in an average of 19 codes for each of the three narratives. During each stage of coding, researchers used memos to document their thinking and rationale for coding items in particular ways and calibrated to ensure that codes were validated. From these codes, the following generalized themes were identified:

- **Critical Thinking Transference:** encouraged transference of ideas from one context to another (narrative to engineering professionalism)

- **Ethical Responsibilities:** allowed application of ethical concerns and analysis of dilemma
- **Contextualizes Professional Responsibility:** made visible engineering responsibilities in variety of contexts
- **Interaction Matters:** encouraged thoughtful exchange of ideas and potential change of perspective based on interaction

## Procedures

Researchers created randomized, group discussion board assignments in the student's corresponding Canvas (Learning Management System) for each narrative and required students to complete the following activities within a two-week time span:

- Step 1: Listen to the critical narrative
- Step 2: Respond to the critical narrative through five focus questions
- Step 3: Respond to at least two other students in the group
- Step 4: Reflect on the conversation and any changes in position

The five focus questions were the same for each narrative and included the following:

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?

The prompt for the reflection post was as follows:

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.

## Results

### *Response Rate and Artifact Generation*

The following data was collected during the pilot study:

Table 2. Responses generated

Narrative	Focus Question Posts	Reflection Posts
The Rhino Hunter	32	14

Hungry, Hungry People	23	13
How do you Solve a Problem Like Fritz Haber	14	8

(Note: Due to two instructors' concerns over scheduling, the third narrative was not assigned in two of the sections)

## Findings and Discussion

### *Theme One: Critical Thinking Transference*

Some students made connections between the critical narratives and other events. For instance, one respondent brought up “wet markets in China, causing significant disease outbreaks” in relation to the “Hungry, Hungry People,” and others connected the “The Rhino Hunter” to engineering projects like the “construction of a dam in order to produce renewable energy” or “wind turbine is great sources of energy.” These connections indicate students accomplishing Bloom’s goal for students to apply and synthesize.

Researchers noted that some respondents struggled with connecting the first two critical narratives to their profession; the first two stories did not involve any clear declaration of an engineering field. However, because Discussion Question #4 specifically asked students to connect the critical narrative to engineering, respondents obliged. For instance, in response to “Hungry, Hungry Hippo,” respondents most often connected the narrative to “environmental engineers”—an easy connection for a story about food scarcity. Another response, though, shows that students lived up to the challenge to connect a narrative about trophy hunting with their profession—mechanical engineering: “Society may put the blame on aircraft designers, and resulting in an 'unethical' situation.” With this response, the student is accomplishing the application cognition criteria from Bloom, as well as evaluating professional responsibility, ethical situations, and societal perceptions of engineers exemplifying dynamic learning.

Even though the last critical narrative—“How do you solve a problem like Fritz Haber?”—focuses specifically on chemical engineering, respondents still made connections to different engineering fields or engineering innovations. For instance one student wrote: “As engineers, especially in Aerospace, we may be tasked depending the company we work on to create a weapon or machine of war. While today a lot of these are much more humane and are created to prevent as much civilian collateral damage as possible, there is still that lingering thought.” With this response, researchers made note of the connection between Haber’s chemical engineering invention and the discipline of aerospace engineering. Based on CT, this student is applying the assigned narrative to their own potential career. Since graduating seniors might have applied to work at local corporations like Lockheed Martin or Northrup Grumman, they are aware that aerospace engineers might be tasked with creating a weapon. After engaging with this critical narrative, this particular student has the “lingering thought” of being tasked with the ethical dilemma of creating a weapon—an example of the student engaging in metacognitive knowledge, as they look forward to their own careers and reflect on the historical example provided in the critical narrative.

Researchers again found that the critical narrative intervention encourages students to practice dynamic learning; they note that: Respondents often used rhetorical questions in posts rather than

making declarations, suggesting that they are acknowledging the tensions presented in the narrative but not yet able to make declarative statements about it (ex. “Do you sell your skills, or do you donate them?” or “The main ethical question that relates to engineers is at what point does something become unethical and what can be done to change that? Along with this, the justification that because they are paying a lot of money what they are doing is okay and ethical. Does paying more money towards a good thing make taking a negative action ethical?”)

### *Theme Two: Ethical Responsibilities*

Most respondents were able to identify the ethical responsibilities of an engineer, as seen in responses like

- “Would this project be ethical and acceptable because it is benefiting the greater good?”
- “I think this story is a good example of how taking the easier route or an alternate idea is not always ethical or good. We have to think about whether we are actually solving the real problem and is this a sustainable and feasible solution.”
- “The most significant concern that may be relevant to engineers is that political officials sometimes like to put undue pressure on an engineer”

These responses suggest that the critical narratives allowed students to identify aspects of professional ethics, including consequentialist and utilitarian approaches to engineering, as well as political and financial influences. The critical narratives also encouraged at least one student to see the “grey” areas of ethical or moral dilemmas that engineers will face in their career: “The intersection of human desire and the good of the planet will always be a blurry grey area, and it’s our job as engineers to consider that in our careers.”

Researchers recognized that the “How do you Solve a Problem Like Fritz Haber?” critical narrative elicited the most direct and comprehensive discussions about ethics. The compelling narration asks listeners to place Haber’s accomplishment on a scale—ranking his ability to solve Germany’s food scarcity with his invention to pull nitrogen from the air along with his WWI war crime of gassing enemies at the front line using similar technology. Because of its successful storytelling techniques, the Haber narrative elicited responses regarding weapons development and the ethics of engineering inventions and innovations. For instance, respondents claimed that

- “Fritz Haber...was a very good engineer – he found solutions to very difficult problems that were manufacturable and scalable. However, he did not have the ethical standards that an engineer need[s].”
- “As engineers, we have an ethical responsibility to those that could be affected by our work. This idea is paramount, and we should never let outside factors influence our work such that it can be used for harm.”
- “In addition, I think that this raises the ethical concern of how do we as engineers balance protecting our country with our own need to achieve and better whatever we can? Haber was almost crazy at the idea of continually making a better weapon in the chlorine gas, but at what point does that desire become so great that a logical reason - such as defending the country - can no longer be given?”

Researchers noted that students are aware that engineers need an ethical framework and guidelines. While some students pointed to Haber’s actions as individual concerns or labeled him

as unfit, these above responses encouraged students to weigh influence, potential harm, and passion in relation to their ethical responsibility as an engineer.

### *Theme Three: Contextualizes Professional Responsibility*

Quite a few respondents reiterated stereotypical notions about engineers and their professional responsibility; for example, some claimed that

- “Engineers are problem solvers”
- “Fritz Haber was an engineer by its most basic definitions: he uses science and technology to solve problems.”
- “Engineers are responsible for massive projects and building our cities, energy grids, and transportation systems.”

Student responses represent Perry’s model [15] of intellectual and ethical development. The lowest level on Perry’s model is a Dualist thinker: “In Perry’s observations, most freshman enter college as dualist, believing that there are clear objective, right or wrong answers” [16]. In line with Perry’s model, another student stated that “I think as engineers, we tend to think very analytically in terms of numbers and percentages instead of with a critical ethical lens.” This regurgitation of the basic “job” of an engineer did not come as a surprise to researchers, as the engineering curriculum at our institution does not have dedicated or unified projects to expand students’ perception of the profession. Different programs introduce the disciplinary or professional guidelines and some professors do refer students to the “rules” of the profession. One respondent explicitly pointed to these professional responsibilities: “When it comes down to it what “rules” matter and what “rules” can be ignored for the sake of solving a problem. Are there natural principals and unspoken rules that can be put into question when it comes to making designs to solve problems.” This response reinforces that this student at least is aware of stated professional guidelines, as well as instances of bucking those guidelines due to profit or political pressures. With this response, researchers were reminded of Freidson’s five-fold typology [17] and how students are not yet aware of how their profession can and will reach beyond that of those they are supposed to serve.

Some respondents went beyond the engineering stereotype, declaring that the engineering profession required more than just applying a technical solution:

- “as engineers, we should always be looking for the long term impacts something can have on society.”
- “Communication is the main relevance to engineers in this story.”
- “I would suggest that engineers should be inclined to consider why things are the way they are and decide whether or not they are right based on a set of values rather than the status quo.”

Researchers noted that particular skills like forethought, communication, and values-based decision making were linked with the profession. The use of the word “should” by many respondents implies that they are aware that engineers responsibilities go beyond technical solutions but, unfortunately, don’t always do so. Here, students are wrestling with what Friedson noted were transcendent values which infuses its specialization with a larger and putatively higher goal.

Researchers also noted that respondents were, at times, able to classify responsibility based on the specialized disciplines in engineers. For instance, one respondent in the “This will not be for a mechanical engineer to figure out but be for a bioengineer to figure out.” With this response, a student majoring in mechanical engineering recognizes that the engineers operate under different models of responsibility. One could read this response as a mechanical engineer passing off duties to a bioengineer because the dilemma is not under the realm of disciplinary knowledge. This reveals how the stark disciplinary divisions have influenced this student; whereas, other mechanical engineering students were able to connect to the critical narrative to their professional responsibility, this respondent passed. For Freidson, this response would relate to the professional ideology of service as it goes beyond serving others’ choices.

#### *Theme Four: Interaction Matters*

Most surprisingly to researchers was the unsolicited declarations of appreciation for the critical narrative intervention—assignments that were not directly tied to their capstone design courses; for instance, one respondent wrote “I like discussing these pod casts and the ethical dilemmas they because I feel like it is preparing me to keep my decision making process to a standard when I encounter future moral “grey areas.” This respondent reinforces that engineering curriculums need to include more pedagogical interventions that do not have clear or singular technical solutions.

Other respondents commented on the actual process of the intervention—particularly the online discussion board aspect in which students were required to respond to their peers and reflect on whether their perspective changed. Even if respondents claimed that their original reaction to the critical narrative did not change based on the interaction, they still noted appreciation for engaging with different perspectives.

- “I do not think my opinion on the story changed after reading my colleague's responses, but I did learn new perspectives on the different ethical concerns in the story. I think that shows how unique each person's thought process is, we can all be given the same information but still arrive at different conclusions.”

These coded responses reveal that the critical narrative encouraged some students to move beyond Dualist thinking in Perry’s model [15] to Multiplicity; they begin to see “that truth is contextual and relative, and since there is not a single correct answer, everyone has a right to his or her own opinion” [16].

Other responses show that some students moved even further up Perry’s model to Relativism and “recognize that there may be multiple answers to a question but not all answers are equal, and specific criteria such as empirical evidence and logical consistency can help them evaluate the usefulness and validity of knowledge claims” [16].

- “I think it's important to analyze any system with many different perspectives and work with people to criticize the analysis with their own perspectives. It's like having someone proofread an essay for you. Oftentimes, they will find errors that you didn't realize you were making or offer ways to improve your writing.”
- “Reading the other responses helped me diversify my own thoughts in regards to the ethical concerns of this specific problem.”

- “My colleague’s responses gave additional insight, into how engineers weigh the benefits and drawbacks of acceptable solutions with bold, crazy ones. The discussion included questioning the intent of marketing and campaigning for bold, new ideas. It also solidified my views in the importance of constraints for engineering projects.”

Because respondents were in the same online discussion groups, they were able to build and maintain relationships, evidenced by many of the respondents praising their peers for helping them see a new or different perspective. Many even directly praised peers by calling them out by name.

These findings cement this study’s goal to have students discussing assigned critical narratives with peers, either online or in class. Due to the packed curriculum of most engineering programs, especially senior design courses, moving the discussion online helped to create buy-in from professors who couldn’t imagine replacing existing content with seemingly tangentially related critical narrative assignment and it allowed the peer interaction needed to get students to reflect on their engagement with the critical narratives.

### **Limitations**

- Small n and lack of minoritized/marginalized students
- Seniors may not take the assignment seriously or see value to complete thoughtfully
- Professors need to provide some sort of grade/completion points to encourage completion of assignments and engagement with critical narratives
- Teaching content takes precedence so faculty need to be persuaded to include these narratives into course schedule
- Critical narratives can be long
- Auditory podcasts could dissuade other types of learners from engaging
- The critical narratives chosen for this study come from public radio productions, which has a specific demographic for audience and goals that may not serve minoritized populations

### **Summary of Themes and Findings**

Recall, during each stage of coding, researchers used memos to document their thinking and rationale for coding items in particular ways and calibrated to ensure that codes were validated. From these codes, the following generalized themes were identified: Critical Thinking Transference, Ethical Responsibilities, Contextualizes Professional Responsibility, and Interaction Matters. Preliminary findings suggest that engagement with critical narratives does help some students make connections between their profession and the broader impacts of engineering work. For example, the critical narratives encourage students to engage in metacognition, apply and synthesize information, practice dynamic learning, identify clear aspects of professional ethics, and see “grey” areas of ethical or moral dilemmas. Prompts to the critical narratives also encouraged students to weigh influence, potential harm, and passion in relation to their ethical responsibility as an engineer. Some students even provided unsolicited declarations of appreciation for the critical narrative intervention. Lastly, interaction with peers concerning the critical narratives encouraged meaningful dialogue about ethical dilemmas that some students might not otherwise engage in throughout the capstone design sequence.

## Lessons Learned

The pilot study helped researchers identify practices that may assist others who are considering implementing critical narratives to encourage ethical and professional development in their courses.

In regards to choosing which critical narratives to use, one should consider:

- Critical narratives should be varied and not overtly focused on a specific engineering field so that students are required to do the heavy lifting of making the connections
- Response questions to critical narratives need to be guided enough to force students to make those connections
- Response questions also need to leave enough room for students to apply the critical narrative to other texts or events

To increase engineering students' awareness of ethical and moral responsibilities using critical narratives, researchers note that:

- Critical narratives need to be engaging
- Critical narratives should elicit some form of empathy, as studies show that students can more fully engage with ethical frameworks
- Students need a clear and specific definition of ethics and/or morals
- Lessen emphasis in discussion questions about the “grey” area, as students repeated this phrase without clear knowledge of ethics

When considering the critical narratives' ability to get students to consider their professional responsibility, researchers note that:

- Narratives cannot have a singular or technical solution
- Some students might not be familiar with or be engaged with the critical narrative because they are all auditory/podcasts
- Narratives should also be selected to represent different demographic groups

In terms of the process and interaction of the critical narratives, researchers note that:

- Online discussions are important, as they created the meaningful dialogue needed to move students to metacognition
- Varying groups by perspective and/or demographics would be helpful, as those groups included more statements of changed perspectives
- Assigning low-stakes/minimal points to the discussion boards encourages more responses
- Reminders to post and/or respond are necessary, as the narratives are not necessarily built into the course schedule

## Future Research

This study was conceived and developed based on experience that the researchers had with critical narratives in sophomore and junior-level honors seminar-style courses. Prior to the pilot

study, researchers were unsure how typical engineering students in the midst of their capstone design projects would respond to these narratives. Would the narratives be perceived as so unrelated to engineering that the broader aims tied to critical thinking around ethics and professional responsibility may be thwarted? Results from the pilot study suggest that most engineering students are open to engaging with these narratives and the connections they are making to ethics and professional responsibility warrants further exploration on the efficacy of critical narrative as a pedagogical tool.

Plans for future research include a comparison of responses to critical narratives by major and other demographic data. We also plan to investigate if and how engaging with critical narratives influences the way students address the broader impacts of engineering work as part of their capstone design projects. Finally, a mixed-methods study is planned to investigate the relationship between student responses to critical narratives and results from the EPRA survey [18],[19]. Additional questions related to the efficacy of specific narratives , audio vs. written format, and comparison of responses to traditional engineering case studies are also topics we have identified for further exploration.

### **Research Team Positionality**

All four authors work at one mid-sized, private, historically White university in the Southeast. We all have doctorates and experience working as tenure-track faculty members. We all have experience with ethics curriculum. Two of the authors have engineering backgrounds and three have social science expertise.

The first author identifies as a white male who is married with two children. His traditional engineering background is in civil structures. As a devoted listener to NPR, this author acknowledges the influence that such programming has on his interpretation of current events and his overall perspective on ethics. Current research interests include ethics in engineering education and service learning in the context of international development.

The second author identifies as a married straight Black man (U.S. descendent of Black people who were enslaved) and person of faith. Growing up in the Midwest, he earned two degrees in engineering as well as a PhD in education. As a graduate student, he published research and designed course work on engineering ethics. He is a tenured associate engineering professor and devoted community servant.

The third author identifies as a cisgender, white woman from a family of educators. Growing up in the northeast, she has earned degrees in English and American Literature, with a focus on gender studies. Her publications reflect her studies in pedagogy, assessment, Rhetoric and Composition, as well cultural studies. Currently, she is a tenured associate professor focused on interdisciplinary studies.

The fourth author identifies as a married white male trained in humanities and education. He is both a faculty member and faculty developer. Research has focused on student learning and assessment.

## Appendix

For our pilot study, we selected three critical narratives. Each reiterated a complex event, problem, or concern that was indirectly related to the engineering discipline. None of the narratives had a singular or correct answer to the complex event, problem, or concern discussed. Below are more detailed synopses of critical narratives in the order that we assigned them, as well as how these narratives helped us address our research questions.

### *The Rhino Hunter*

“The Rhino Hunter” follows professional hunter Corey Knowlton through his experience of paying \$350,000 for a hunting trip to Namibia to shoot and kill an endangered species. In this critical narrative, the producer Simon Adler follows Knowlton on his trip to Namibia, interviews “Namibian hunters and government officials, American activists, and Kenya’s former Director of Wildlife, Richard Leakey.”

We assigned this narrative because it exposes the complexity of sustainable conservation for a United States audience that is primed for a narrative about animal activism and gun control.

Thus, this narrative addresses our research question about ways to enhance engineering students’ development of ethics and professional responsibility in a variety of ways:

- because this narrative fully develops Knowlton as a the protagonist and asks listeners to sympathize with him regardless of their personal hunting or conservation beliefs, students are left to question their own ethical boundaries in regards to hunting an endangered species
- because it does not conclude with a definitive answer on whether Knowlton’s actions should be viewed as positive or negative, students have to consider what role—if any—professional engineers might have in animal conservation

We assigned this narrative first because there is no clear mention of engineering throughout the narrative; therefore, students are required to think critically and make a connection between this narrative and engineering disciplines, which addresses our second research question. We want students to begin to see engineering as more than just a technical discipline, and this narrative requires them to identify how engineers might solve the complex problem of conservation and do so while considering the broader social and financial impacts. For instance, the narrative reminds students about the economic constraints of conservation as well as cultural differences between pro- and anti-hunters.

### *Hungry, Hungry People*

For the second assignment, we asked students to engage with the “Hungry, Hungry, People” critical narrative. *This American Life* Producer Alex Blumberg interviews Jon Mooallem about his story on the early 1900s food shortage in the USA. One solution proposed to this complex problem is introducing hippopotamuses into the relatively unproductive swamp lands of southern Louisiana.

Like “The Rhino Hunter,” we assigned this narrative because it does not specifically point to a singular solution to a complex problem like food scarcity. Rather, this narrative reviews the complicated thought processes involved in trying to solve problems with seemingly ingenious

ideas. We assigned this narrative to help us address our second research question, as students were required to

- Identify ways this critical narrative connects to engineering
- Formulate ways that this solution might cause other problem
- Consider the public health, safety, and welfare of the community that needed a complex problem solved (ABET SO-2)

Students also had to consider the ethical consequences of introducing a non-native species into the environment to solve one problem and what role professional engineers have—if any—in solving this problem. Here, students had to consider their own ethics and connect them to their professional responsibilities.

### *How do you Solve a Problem like Fritz Haber?*

The final critical narrative “How do you solve a problem like Fritz Haber?” most closely relates to a specific engineering disciplines; however, Haber’s chemical engineering discipline was not the primary focus on the critical narrative. Instead, listeners are asked to determine how Haber’s inventions and actions should be weighed in terms of “good” or “bad.” As Sam Kean explains, Haber’s life story is complicated, tied to nationalist tendencies, and amazing inventions. A young chemist in Germany in the 1900s, Haber solves the biggest problem facing his country: how to feed a growing population by figuring out how to produce fertilized using atmospheric nitrogen. Even though his discovery earned him a Nobel Prize, he was also deemed a war criminal because of his connection to the development and deployment of chemical weapons on the front lines of WWI.

With this critical narrative, students have to focus on the ethical concerns of engineering, particularly weapons development, and thus address our first research question. Students are also required to consider what their professional responsibility might be in relationship to innovations and inventions. After Haber’s death, pesticide chemicals developed through his research institute were used by the Nazis in gas chambers.

## References

1. ABET. (2019). Criteria for Accrediting Engineering Programs, 2019 – 2020. Retrieved Feb. 27, 2020, from <https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/>
2. Dewey, J. (1933). How We Think: A Restatement of the Relation of Reflective Thinking to the Educative Process, Lexington, MA: D.C. Heath
3. Bloom, B. et al. (1956). Taxonomy of Educational Objectives. Handbook I: Cognitive Domain, New York: David McKay.

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4. Anderson, L. et al. (2001) *A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, New York: Longman, complete edition.
5. Pohl, M. (2000). *Learning to Think – Thinking to Learn: Models and Strategies to Develop a Classroom Culture of Thinking*. Hawker Brownlow Education
6. Ahern, A., Dominguez, C., McNally, C., O'Sullivan, J.J., & Pedrosa, D. (2019). A literature review of critical thinking in engineering education. *Studies in Higher Education*, 44(5), 816-828.
7. Cloete, A. (2001). Solving problems or problem solving: What are we teaching our students? *Proceedings, ASEE Annual Conference*.
8. Mina, M., Omidvar, I., & Knott, K. (2003). Learning to think critically to solve engineering problems: Revisiting John Dewey's ideas for evaluating the engineering education. *Proceedings, ASEE Annual Conference*.
9. Lunt, B. M., & Helps, R. G. (2001). Problem solving in engineering technology: Creativity, estimation and critical thinking are essential skills. *Proceedings, ASEE Annual Conference*
10. Abumrad, J. & Krulwich, R. (Narrators). (2015). *The Rhino Hunter*. Radiolab. New York: WNYC Studios. Retrieved March 23, 2022, from <https://www.wnycstudios.org/podcasts/radiolab/articles/rhino-hunter>.
11. Mooallem, J. (Narrator). (2014). *Act Three: Hungry, Hungry, People*. In A. Blumberg (Producer), *This American Life*. Chicago: Chicago Public Media. Retrieved March 23, 2022, from <https://www.thisamericanlife.org/518/except-for-that-one-thing/act-three>.
12. Abumrad, J. & Krulwich, R. (Narrators). (2012). *How do you Solve a Problem Like Fritz Haber?* Radiolab. New York: WNYC Studios. Retrieved March 23, 2022, from <https://www.wnycstudios.org/podcasts/radiolab/segments/180132-how-do-you-solve-problem-fritz-haber>
13. Glaser, B., Strauss A. (1967) *The discovery of grounded theory: strategies for qualitative research*. New York: Aldine de Gruyter.
14. Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. London, England: Sage.
15. Perry, W. G., Jr. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt, Rinehart, and Winston.
16. Barkley, E. F. (2010). *Student Engagement Techniques: A Handbook for College Faculty*. United Kingdom: Wiley.
17. Freidson, E. (2001). *Professionalism: the third logic*. Chicago: The University of Chicago Press.

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18. Bielefeldt, Angela R., and Nathan E. Canney. 2016. "Changes in the Social Responsibility Attitudes of Engineering Students Over Time." *Science and Engineering Ethics* 22 (5): 1535-1551.
19. Bielefeldt, A. & Canney, N. (2012). "Engineering Professional Responsibility Assessment." Retrieved March 30, 2016 from [http://spot.colorado.edu/~bielefel/resources/engineering\\_professional\\_responsibility\\_assessment\\_pref2012.pdf](http://spot.colorado.edu/~bielefel/resources/engineering_professional_responsibility_assessment_pref2012.pdf).