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A Framework for the Classroom Use of Science-Fiction to Enhance Ethical Design Skills among Engineering Sudents

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I. Introduction to Current Engineering Ethics Education

Modern society is often at the whim of technology, and therefore at the whim of the people who create technology: engineers. Unfortunately, for decades, engineers have been educated from an almost entirely technical standpoint. Our education system continuously graduates engineers who know how to build amazing projects but have nearly no concept of how these projects will change the societies they are built within. Thankfully, in recent times, this has been changing. As the power of technology in our modern world has grown to be undeniable, so has the need to properly design, build, and regulate it. Across the nation, engineering programs have adopted more rigorous forms of engineering ethics education by embedding it in capstone design courses, introduction to engineering courses, or even by establishing separate courses entirely dedicated to ethics in the engineering field [1].

Currently, one of the dominant paradigms for teaching engineering ethics stems from real-world case study analysis. In 2018, Robert McGinn published *The Ethical Engineer* [2], a textbook designed to teach engineering ethics in a modern way. In it, McGinn analyzes eighteen separate case studies of real-world events. These events range from the advent of Google Street View to the Space Shuttle Challenger Disaster. These case studies are a valuable way of approaching engineering ethics education, as they introduce real engineers and real projects to examine the choices that were made in the design process of some of humanity's most tragic failures and spectacular successes.

II. The Value of Science Fiction

While historical case studies are an important tool for developing ethical engineering skills, unfortunately, the exclusive use of them can leave blind spots. If a class only examines historical events, it will neglect the study of technologies that are on the horizon, which graduating engineers will actually work on over the course of their careers.

Right now, some of the technologies that will shape the next decade and beyond are quite clear. It's obvious that virtual reality, artificial intelligence, and autonomous vehicles will all play a role in shaping our future. But as these technologies develop, there aren't case studies to use to properly analyze or discuss them in a classroom setting. This is where science fiction can play an important role. Writers have been writing about these technologies for as long as we have imagined them. In fact, the term Metaverse first appeared in the 1992 novel *Snow Crash* [3], more than three decades ago. In a 2019 article, Michael Gillon [4] wrote "[The] intimate relationship between science and science fiction should not come as a surprise. Indeed, both disciplines are basically two parallel methods to answer questions of the form: 'what if…?'" This observation is even more relevant to the field of engineering. In fact, the entire engineering design process boils down to one question: "what if … existed?" The goal of engineering ethics education is to get engineers to carefully answer this question, going beyond the technical into the societal, humanitarian, and environmental impacts of their work. These very themes are of great interest to science fiction writers, as they make for intriguing and powerful stories. In a 2006 essay, the scientist-writer duo Alice and Bill Pomidor [5] wrote "the best science fiction

knits together a collection of cold scientific details, bringing the future to life to present the human face of technological change." This idea gets to the crux of the benefit that science fiction can bring to an engineering ethics classroom.

There are special considerations that must be made when dissecting a science-fiction story rather than a true one. For example, every attempt should be made to tie the fictional future to real-life technologies in development. Furthermore, since science fiction narratives are entirely invented, students often must do much more complex thinking to understand the society in which the technology developed, which requires imagination and the skills to project a technology into the future. These considerations can be challenging to track for each individual story, which led to the genesis of this project.

III.   Methodology: The RRCD Framework

The purpose of this project is to design a framework to allow an engineering instructor to quickly and easily integrate a piece of science fiction into their classroom for the purposes of ethical analysis. To accomplish this, we designed the RRCD framework. To begin with, RRCD stands for four question types: Recall, Reflect, Challenge, and Decide. When these question types are answered as a sequence in relation to a piece of science fiction content, they are designed to encourage students to form connections between the narrative and the real world, challenge dominant ideas about an emerging technology, and generate opinions of their own about the future of said technology. The RRCD framework is based on Bloom's Taxonomy, which is an educational framework that has been used for decades by teachers from K-12 to university and beyond. Bloom's Taxonomy includes six categories of thought: knowledge, comprehension, application, synthesis, evaluation, and creation [6]. In the next few paragraphs, we will use the vocabulary of Bloom's taxonomy to outline how the RRCD framework is intended to encourage a pattern of thinking that develops ethical design skills. Additionally, we will cover how an instructor should design RRCD questions. Examples of the questions can be found in the next section, which outlines the design of a classroom activity using this framework.

The first step to using the RRCD framework is for an instructor to identify an interesting science-fiction narrative. We intended for this to be a short film, a clip from a longer movie, a short story, a passage from a novel, or a podcast episode, though other methods of presenting a narrative may work. In our experience, the best way to find interesting science-fiction narratives that are fruitful for ethical discussion is to be a regular consumer of science-fiction content. This content can be found among the most-watched movies and highest-profile books of each year. However, to find lesser-known short-form content, instructors can check lesser-known but thriving science fiction hubs like the YouTube channel "DUST" or the magazine "Clarkesworld".

Once the material has been identified, thought should be given to the specific subject matters within the narrative that would be most interesting to examine. For the purposes of this activity, technologies that are based in real science or that are currently in development will likely work best, as they will have the tightest connections to reality. When these subject matters

are identified, the question design process should begin. Instructors should brainstorm an RRCD question sequence for each subject matter that they identify as relevant to their course.

Within the framework we designed, the first type of question asked to the students should be a "recall" question. These questions should be designed to allow students to pull specific details from the narrative, such as how a technology worked or what the result of some event was. This is the first and second category of Bloom's Taxonomy, which asks students to remember and understand information that was presented to them. These questions serve as a warm-up, as they don't require higher-level thought. However, it should also call certain story elements or plot points to attention for the following questions.

The second type of question in the sequence is a "reflect" question. A well-formed "reflect" question should encourage the student to make a connection between the narrative and something they've encountered in the real world. This relates to the third and fourth level of Bloom's Taxonomy, which asks students to apply and analyze information they've learned, read, or experienced. These questions should begin with a phrase such as "Think of a time when…?" or "Have you ever…?" They should then end with a twist that asks them to draw a connection between that experience and the story presented. We believe that the connections made at this point are especially vital to the overall activity because they bridge the gap between the fictional world presented in the narrative and the real world. The connections students make at this point push them to ask questions of their own, such as "What had to happen to make our world end up in a reality like the one from the story?" or "Given the advent of this new technology, how realistic is this scenario?" These questions should be very similar to the ones an engineer needs to ask themselves in the design process as they project the consequences of their work into the future.

The third question type is a "challenge" question. "Challenge" questions should encourage students to challenge the dominant ideas surrounding a technology (or potential technology). This type of thinking falls into the fifth and sixth levels of Bloom's taxonomy: evaluation and creation. Well-formed questions of this type should embolden students to reject their initial ideas about a story or technology. If an instructor recognizes that there is a trivial ethical conclusion from a particular plot point or story, they should challenge their students to invent their own scenario where that conclusion doesn't hold. This sort of creative thinking reaches the upper echelons of Bloom's Taxonomy and will be a valuable exercise in the engineering classroom.

The final question along the sequence is a "decide" question. These questions are not about making concrete decisions as the name may indicate, but rather about encouraging students to communicate and debate their personal ideas about the topic. "Decide" questions may ask students about their hopes and concerns for a certain topic or simply ask for their opinion on a certain idea. The hope for these questions is that students will share their viewpoint and defend it. This is another example of fifth-level Bloom's Taxonomy thinking, as students evaluate their own personal feelings on a subject. "Decide" questions should generate good discussion in small groups, especially if two students share differing opinions. Debate should be encouraged, as it

helps students flesh out their opinions in defense of them. This further develops ethical design skills as it encourages the free sharing of ideas and concerns in a similar manner to that which is necessary within engineering design environments.

The following graphic quickly explains the sequences of questions.

The RRCD Framework

A sequence of questions designed to spark meaningful discussion on the ethics of a science-fiction narrative in a classroom setting

Recall

Students are asked to recall a story element or plot point from the narrative.

Example: What types of goods were delivered by the drone delivery service in the film? How did the actual delivery technology appear to work?

Reflect

Students are asked to share something they've experienced, encountered, or read about that relates to the presented story in some way.

Example: Think about the last time you got an item (food or otherwise) delivered to you. Was it fast or slow? If that delivery had been via drone, what would have been different?

Challenge

Students are asked to challenge dominant paradigms about an idea and create an argument for or against said idea.

Example: Imagine there was a proposal to install a drone delivery service in your neighborhood and you must speak at a meeting to oppose it. What would you say?

Decide

Students are asked to share their opinions, feelings, or ideas about a presented technology.

Example: What is your opinion about drone delivery? Do you think it will make your life better or worse?

Classroom Testing

After developing this framework from a conceptual standpoint, it was important to engage it in classroom testing. In order to accomplish this, I approached the instructional team for the Electrical Engineering ethics course at my home institution, the University of Maryland. This course is entitled ENEE200: Technology and Consequences: Engineering, Ethics, and Humanity. With their help, I began to write a classroom activity for a selected piece of science fiction work.

The work we chose is the short film called Skywatch [7] by a filmmaker named Colin Levy. The film is set in a near future reality where drone delivery is common and widespread. It follows two young characters who have found a way to hack the drones and swap unrelated deliveries, often to comedic effect. However, when one hack goes bad, the delivery company quickly catches on and uses its vast drone network to hunt down the protagonists.

The decision to use this film as the basis for our activity was made for several reasons. First, the film is short, running only ten minutes and thirty-four seconds long. This makes it easy to fit into a standard class period with plenty of time for discussion. Secondly, the film depicts a near future where most of the technology on screen is actually being developed by professional engineers today. This makes it incredibly relevant and introduces the possibility that students have encountered the subject matter in research labs, internships, or other early-career experiences. Finally, the film is fruitful for ethical analysis, as it introduces a dystopian scenario that raises interesting questions about how we should develop, release, and regulate certain technologies.

The first step in this process was to identify the specific subject matter within the film that would be the most educationally beneficial for students to discuss. After significant brainstorming, the instructional team and I arrived at the following four topics of discussion: drone delivery, robotic "use of force", public utility law, and dystopian storytelling. Each of these contains a contemporary relevance, the potential to have a broad impact on how our society works, and a special pertinence to the film.

After the discussion topics were identified, the question-writing process began. After brainstorming, drafting, editing, and rewriting, I arrived at the following discussion prompts.

Discussion Prompts for Skywatch

	Drone Delivery	Robotic Use-of-Force	Dystopian Storytelling	Public Utility Law
Background Information	In recent years, logistics companies like Amazon and Walmart have announced plans to build networks of drones that buzz	Technology, security and warfare are deeply intertwined, as they have been for centuries. In recent years, engineers have worked to create	A dystopia is "an imagined state or society in which there is great suffering or injustice, typically one that is totalitarian or post-apocalyptic."	According to legal resource hg.org, utilities are defined as "essential commodities or services, such as water, electricity, transportation, or communication provided to the public by

	around American cities and suburbs, delivering consumer goods in as fast as 30 minutes. These networks have been slow to materialize, but still attract billions of dollars in investments and the attention of small startups and mega-corporations alike. In fact, in 2022, McKinsey & Company estimates that more than 2,000 drone deliveries occur each day worldwide. As this number expands, we must consider what this technology could mean for the future.	autonomous systems that allow machines to work without humans. This may seem beneficial when it's a Roomba vacuuming your floor, but when this technology is applied to autonomous drones that drop grenades, ethical concerns arise. In this discussion group, we will think about and discuss the reality of autonomous technology when it comes to use of force. Additionally, we will examine the differences between violent and non-violent forces.	Dystopian futures can be used in stories to accomplish a wide variety of goals, but one common use is to demonstrate the destructive potential of new technology. Books/Movies like *Ready Player One* and TV shows like *Black Mirror* warn about the futures of digital technology, but a wide variety of technology can be indicted with dystopian tales. In 1990, *Jurassic Park* showed us a glimpse into a reality where biological tech goes awry, evolving into 2022's *Jurassic World*: *Dominion*, a dystopian future where dinosaurs roam free across the Earth.	private business organizations." When something is designated as a utility, it often provides you a basic guarantee to access it in your home, if you can pay for it. These can be provided directly by the government, or by a private company in what's known as a public/private partnership. In public/private partnerships, oftentimes your choice of provider is limited. For example: if you were unsatisfied with the energy company providing you electricity, it is very unlikely that you could switch to another company, because your home, neighborhood, and town only has the required electrical equipment from a single company.
Recall	What types of goods were delivered by the drone delivery service in the film? How did the actual delivery technology appear to work?	In the film, where is force used? What was the situation, and what were the operators trying to protect? Think about both violent and non-violent forces.	Using the definition above, would you classify the future presented in the film as a dystopia?	Do you think that the drone delivery service in the film is defined as a utility? What clues can you find in the film that may indicate its legal status?
Reflect	Think about the last time you got an item (food or otherwise) delivered to you. Was it fast or slow? If that delivery had been via drone, what would have been different?	Think about a recent news story that involved violent force being used. How would the situation have been different if it had been a drone or robot using the force?	Have you read or watched a dystopian story recently? Share what the story was about, and what it may have been trying to warn us about.	What utilities do you have at your place of residence? What companies provide them? (feel free to use the internet to find the answer to this question)
Challenge	Imagine there was a proposal to install a drone delivery service in your neighborhood and you must speak at a council meeting to	Is there a scenario where equipping technology with more capability for "lethal force" is helpful or beneficial for society?	Is dystopian storytelling necessary? Why or why not? Can you think of any downsides to telling stories about dystopian futures?	What potential benefits and issues can you see with designating a certain service a "utility"? What conditions should something need to meet to become one?

	oppose it. What would you say?			
Decide	What is your opinion about drone delivery? Do you think it will make your life better or worse?	What is your opinion about robotic use-of-force? What are your hopes and concerns about the future of use-of-force?	Does telling and sharing dystopian stories impact our society in any meaningful way? If so, does it help or hurt our ideas about the future?	In the real world, would you like a drone delivery service to be defined as a utility? If so, would you rather it be provided by the government or through a public/private partnership?

After creating the prompts, I submitted them to the instructional team, who helped to make small adjustments to the questions to relate them directly to the topics and vocabulary they were teaching during the period this activity would take place. Then, we had further meetings to discuss the exact logistics of this activity. In truth, the RRCD framework outlined in this paper could be integrated into a classroom in a variety of different ways. However, I include the specific logistics of the Skywatch classroom activity as a starting point for an instructor who is interested in completing a similar activity.

First, the questions were divided up by discussion topic. Each topic had a single page that included a small snippet of background information about a technology, followed by individual questions for recall, reflect, challenge, and decide. We then created a packet that included the page for each of the four topics. Students were divided into groups of six or seven, and each group got a question packet.

I was given a one-hour and fifteen-minute class period to complete the activity. At the beginning of class, I spent five minutes introducing myself and the idea of using science fiction to discuss ethics. Then, we watched the film for ten minutes. After the film, I spent five minutes introducing the activity. Then, each group was given ten minutes per topic to discuss the questions. Finally, we used the remaining fifteen minutes to debrief the activity, discuss key takeaways, and collect feedback through a Google Form.

IV. Data and Results

For a brief and preliminary method of assessing how this activity worked, I solicited feedback from students. This was collected by asking them to fill out an anonymous Google Form before the class period concluded. We received sixty-nine responses to this request for feedback. Below are the results:

Do you think you and your group had an engaging conversation?

No	Other	Yes
1	0	68

Do you think that this format of teaching and learning is effective?

No	Maybe	I'm not sure it's for me.	Yes
1	1	1	66

V. Conclusions

This single-classroom experiment is just a very preliminary form of testing the RRCD framework. However, this early trial seemed to be a success. In their responses, students overwhelmingly believed that the activity sparked engaging conversations. As an instructor teaching engineering ethics, this should be the ultimate goal. Even if students strayed from the questions at hand, they still engaged in forty minutes of spirited discussion about the future that was presented in this film. These discussions undoubtedly deepened the students´ conception of the link between technology and society and therefore increased awareness of how their work will impact the world we live in. In our modern landscape of technology, increasing this awareness amongst engineers has never been more important. Before the RRCD framework can be definitively recommended, however, it must be tested further. Over the next few years, I hope to test this in more classrooms, with more input and feedback from instructors and students alike.

VI. Acknowledgments

VII.   References

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