Instructing First-Year Engineering Students on the Ethics of Algorithms through a Role-Play

Abstract

Introductory engineering courses teach a range of foundational topics to first-year engineering students. An ethics component is often presented as one of these broad topics, usually through a case study module that examines past catastrophic engineering events. In this Research-to-Practice paper, we present findings from a study using role-play scenarios (RPSs) to teach ethics to first-year engineering students. Role-play discussions serve as a collaborative means for students to discuss and negotiate ethical issues to reach an actionable consensus. We designed a role-play scenario that places students on a university task force that is evaluating the adoption or rejection of facial recognition technologies (FRT) to track and identify the COVID-19 reporting status of students, faculty, staff, and visitors. Students were asked to prepare and then participate in role-play discussions which were then assessed for learning. The data supporting this research comes from the role-play discussion transcripts of 86 first-year engineering students who participated in four sections of an undergraduate engineering concepts class during Fall 2020. Our findings show that students successfully identified a breadth of ethical issues, dilemmas, and topics related to the use of FRT on campus. In addition, students employed an ethical reasoning process to create a group consensus with their peers, supporting the overall goal of developing a more situated understanding of ethical decision-making.

1. Introduction

Engineers leverage a combination of skills, knowledge, and experiences to innovate and create technologies across domains. Through a micro-view, these technologies have the potential to affect change by making processes more efficient or cost-effective. When taking a macro perspective, engineers can alter how society interacts with the world around them. Engineers may work in a breadth of diverse fields, but ethical responsibility is a primary tenet that underlines professional engineering. When the result of engineering decision-making can be the difference between mission-critical products and services working as intended, and the worst-case scenario of harm or injury to people, it is fundamental that engineers behave in ethically responsible ways [1], [2]. Therefore, it is imperative that higher-education institutions prepare students by providing them with the technical skills needed to be successful and the ability to demonstrate ethical thinking.

Ethics instruction in engineering education has attempted to cover a minimum training threshold that all institutions need to demonstrate through their curriculum. Ethics instruction in technology fields has been accomplished in various styles and is growing each year [3]. Guidelines such as those outlined through the Accreditation Board for Engineering and Technology (ABET) require ethics instruction but leave the specifics of implementation to the institution [4]. This gives some flexibility in incorporating the content among the other

requirements that engineering programs need to meet. Ultimately, ethics instruction should emphasize preparing students to think critically and flexibly to solve problems [5]. This is especially important in today's technological climate, where algorithmic thinking and decision-making are fundamental parts of technological innovation.

First-year engineering courses provide an inherent opportunity to discuss how ethics affects professional engineers. Although these courses are foundational, they can set the expectation of ethics-related

discussion in future courses and throughout the students' academic careers. Students must be prepared for the impact of their decisions on society. To do this effectively, students must be exposed to other perspectives and ways of thinking about everyday scenarios that include ethical dilemmas. Being aware of the voices of different stakeholders is a small step, but it is the first among many that students need to take to demonstrate ethical responsibility.

To address this need for perspective-taking and identification of ethical dilemmas, we used role-play scenarios (referred to as RPSs) to provide students with fictitious real-world experiences in a collaborative learning environment. Students are placed in an RPS and are exposed to a variety of stakeholders who they must negotiate with to make an actionable decision. This paper will explore first-year undergraduate engineering students' identification of ethical issues in a context-specific RPS on facial recognition technology (referred to as FRT).

2. Relevant Literature

Engineering ethics instruction has been acknowledged as a fundamental learning goal for students to be trained before they graduate into the professional workforce [6]–[8]. Although the general principles of ethics in engineering are standard and reflect ethics in other professions, engineering professionals have to deal with applying this way of thinking in a constantly changing world. As Barakat & Carroll [9] describe ethics as "the side of engineering that has to deal simultaneously with a changing profession and a human and societal aspect, which is also changing." [pg. 3]. All professional engineers share engineering values that promote responsibility, fairness, loyalty and avoiding conflicts of interest, discrimination, and unfair competition [10]. These values are expressed across other domains in the institution, but they are especially emphasized in the field due to the mission of care and standard of work professional engineers must-have. According to Hamad et al., who synthesized the attributes of an ethical engineer from other publications and researchers, ethical engineers should [11]:

1) have the skills to identify an ethical dilemma and all the constraints related to such a dilemma.

2) communicate effectively with other team members to assess barriers and any possible consequences.

3) be competent and service-oriented.

4) be creative and have strong project management skills.

5) have the skill to revise plans/actions/options.

Role-play scenarios are a useful way to depict the complexities of being an ethical engineer. RPSs allow for introducing relevant topics to students through case studies that they can explore on a deeper level [12]–[14]. RPSs do this by helping students situate themselves in scenarios through character roles. As the scenarios are developed for the learning environment, they let RPS administrators take a fictive approach to discuss topics of interest realistically and genuinely. Doorn & Kroesen [15] outline three classes of objectives for using role-play scenarios associated with their past use: 1) teaching communication skills, 2) teaching ethics (referred to as micro-ethics), and 3) broadening students' perspectives (referred to as macro-ethics). Depending on the goals of the activity, and the way that the case is developed, an RPS may attempt to achieve one or more of these goals.

The RPS activity is a collaborative event that allows students to explore different perspectives in a scenario and help shape a multifaceted approach to thinking about a topic [12], [13]. Students are

actively engaged through the activity as they are tasked with interacting with others on a deeper level than just reading the source material and writing the answer in an essay [16]. Students need to develop a fuller understanding of the different elements at play and strategize how the interactions with other participants may go.

With the importance of introducing engineering students to ethical situations, the first-year engineering environment is an appropriate location in the curriculum to start introducing the topic of engineering ethics [17]. In some research venues, there is little discussion of engineering ethics [18], and recent reports of the resurgence of implementing ethics in the first-year engineering classroom [19] and the need to provide more prominence to ethics within the curriculum [20] give credence to the timely nature of this work.

3. The Role-Play Scenario – Facial Recognition Technology

The role-play scenario we developed for our reaching explores a fictitious campus, Andrew Hamilton University (AHU). At AHU, a task force has been set up to monitor and maintain campus health as a result of the COVID-19 pandemic. Currently, the campus uses a mobile application to track COVID-19 symptoms, which informs the administrative decision-making processes surrounding the safety of people on campus. However, it is difficult to enforce the use of the application in a systemic way. Therefore, a proposition for using biometric facial recognition technology (FRT) has been brought to the administrators to curtail missed reporting on the mobile application. Members of the task force are asked to provide justification based on the specifics of their role for whether FRT should be used on campus and how it could be implemented. The FRT case study and RPS activity explore topics related to communicating as a professional engineer and developing students' understanding of both micro and macro-ethics.

The role-play case scenario provided to participants can be found in Appendix A. The roles assigned to participants can be found in Appendix B. Further details of the case, examples of similar cases, and the application of role-playing for ethics are available in the following related papers [20]–[22].

4. Data Collection

Data were collected from a first-semester course on engineering concepts at a large public university in the U.S. The class serves as a component of a first-year engineering program and introduces students to engineering data analysis with Excel, engineering design, and professional skills. Students are also exposed to industry-related engineering problems and the ethical impact that professional engineering can have. The class was instructed through synchronous, online instruction for each of the four-course sections. Each course section had between 39 and 45 students, totaling 169 students with three total instructors.

Aligned with the course outcomes of providing first-year engineering students with a broad understanding of engineering concepts, the course introduces ethics as a core instruction module. The course included three mini-projects, and the ethics case study project was the second of the three projects. The project included both in-class and out-of-class assignments over three-course days. Students are assigned reading materials and resources from both peer-reviewed and mass media publications, along with videos covering interviews with professionals related to A.I., machine learning, and the use of algorithms in technology. After engaging with the learning material, students are given

the role-play scenario and assigned specific roles to play. Roles are assigned randomly but are paired together based on the possibility of fruitful conversations between the participants.

Eighty-six (86) students, split into thirty (30) groups, participated in the RPS activity. They were asked to use the materials in the case study and any information from the resources to guide how their specific role would behave in the scenario. The activity was a semi-structured conversation that lasted about 30 minutes between 2-3 participants and a moderator who stepped in only to move the conversation forward. As part of the activity, students were asked to reach a group consensus on deciding what the committee should do. As the RPS activity encourages students to have an open discussion on the case, the grading assessment is based on active participation in the activity.

The data presented in the next sections of this paper were part of the student role-play transcripts. The transcripts and discourse within were edited minimally to remove private identifiers or personal information. The content of the discussion was not modified.

5. Analysis and Discussion of Themes

This section explores the RPS participant's discussions of adopting FRT on the campus. After reviewing the transcripts from the RPS activity, we identified significant themes found across the discourse. For a theme to be considered significant, it was discussed by ten or more participant groups in the RPS transcripts. Three overall themes were expressed through the role-play discussion: 1) a focus on the "bigger picture" or a macro perspective; 2) the future impact of normalizing FRT; and 3) concerns about safety, privacy, and bias. The number of groups that discussed each of the themes can be seen in Figure 1.

Figure 1: The number of RPS groups that discussed each significant theme (N=30)

5.a. Focus on the Bigger Picture

The first theme highlighted a focus on the bigger picture or a more macro view of the ethical responsibilities placed on the task force (and society to a larger degree) in the scenario. Of the 30 RPS groups, 28 groups discussed this theme (Figure 1).

Students took the perspective that reducing or eliminating the effects of the COVID pandemic justified the use and consequences associated with FRT. These students argued that higher education institutions would have to make difficult choices, and not everyone would agree with their decisions.

"Most importantly, it's protecting the students and staff… and with the facial recognition technology and monitoring the students, we can allow for extremely efficient contact tracing, especially since we won't need to put people in doorways to check temperatures. Because at that point, it may be too late and they might be contagious." - (Student 1)

"Like, no policy ever makes enough people happy, and to be honest, schools really aren't democracies." - (Student 2)

Some students specifically addressed their feelings of ambivalence and uncertainty toward FRT. However, they also argued that gently compromising on personal values was an understandable justification for using FRT if it helped overcome the pandemic.

“So, the reason why I truly believe this technology will work is because – here’s the deal – this COVID is not going away. If we quarantine for a year, if everyone

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Focus on the Bigger Picture

Focus on the Bigger Picture

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stayed in their houses for a year, yes, it would go away. But we can’t do that. We can’t do that off our economy… we can’t do that for our students.” - (Student 3)

“It’s just, we as a country believe in a lot of personal freedom and stuff, but at certain points you have to give in a little bit. Because this isn’t like, protecting against attacks or something like NASA does, or the NSA. This is a pandemic, you know?” - (Student 4)

“I understand there’s a little bit of a privacy issue, but I think that for the interest of health, we could figure something out.” - (Student 5)

5.b. Future Impact of Normalizing FRT

The second theme was understanding how accepting FRT would affect the future adoption of similar technologies. Many students viewed the pandemic as an event that would not be around forever. Whether 6-months or 2-years, the pandemic would eventually end. But how would this change affect students and higher education institutions in the future? Of the 30 RPS groups, this theme was highlighted in 15 group discussions (Figure 1).

Several students discussed potential concerns about how FRT would affect people and higher education systems past the COVID-19 pandemic.

“If we were to implement this on campus, we would be grooming the next generation of workers as commercial targets and be used to people watching them, and then different agencies or companies could take advantage of that false sense of security that they’ve developed.” - (Student 6)

“So basically, the university would be spending all this money to buy the technology and then pay people to install it, just to take it out whenever the pandemic is over? That doesn’t make sense.” - (Student 7)

Some participants expressed that while the technology may not be completely accurate yet, adopting the technology and providing diverse data types would help fix some of the early issues with it. However, if no one adopts technology and actively works towards improving it, no progress will be made.

“One benefit of doing this would – it opens room for growth of the technology itself, there are versions of facial recognition that can identify temperature changes, so by [adopting FRT] we could not only identify someone, we could

check their temperature when they walk in buildings, so it would cut the need for extra personnel to do that, which is great, because that puts less people at risk.” - (Student 3)

There was also some discussion about how these technologies have already become normalized in society. These students discussed how technology is seemingly already part of many students’ lives. This is most visible in how people interact with mobile devices that use FRT for authentication processes or as filters on social media applications.

“Think about how many apps every student probably has on their phone that use facial recognition just to login. Their face is already stored through numerous apps that they use every day… and those companies are constantly getting hacked. So honestly, I don’t think privacy would be an issue. I think any security concerns could be addressed before the app would be rolled out, and anything that would fall through the cracks would be quickly rectified.” - (Student 8)

5.c. Concerns about Safety, Privacy, and Bias

The third theme outlined significant safety, privacy, and bias concerns introduced by both the datasets on which the FRT was being trained and due to the faulty decisions that the technology could potentially make. Of the 30 RPS groups, this theme was highlighted in 26 group discussions (Figure 1).

Students were overwhelmingly doubtful that FRT would drastically improve containing the spread of the virus on campus over other reporting techniques, such as using the mobile application that was already institutionalized in the case study. The problems and the people who understand how to solve them were not accessible or easy to use at this point in time.

“This technology… there’s obviously some inaccuracies that could happen. I believe that with the face masks and other headwear, sunglasses, religious wear, it could make the facial recognition a little bit tricky. So, I think there could be a different approach as to how we’re going to successfully contact trace people and I just think that the facial recognition technology with these inaccuracies in the system, it could create discriminatory bias and just jeopardize people’s lives. I think there’s a better approach than this.” - (Student 9)

“At least with problems that are involved in the app, it’s sort of issues that everyone experiences, so they can put in their two cents and try to fix it, whereas problems with facial recognition, it’s a pretty small percentage of people who understand how the algorithm even works, not even how they can begin to start to fix it.” - (Student 10)

Privacy and safety were two concerns discussed by almost every team in the RPS activity. The concerns were related more to the dangers presented through the adoption of FRT.

“My main concern is the safety of the students, and I think a restriction we can put on this is – I don’t want to see a public list of who is at risk or who is infected, because I think that could lead to student confrontations and bullying on campus.” - (Student 11)

“No system is ever foolproof so the idea that all of these students’ information, along with their faces, and someone is supposed to be accessing that information could be more dangerous than just a name and some information because it has their face, too.” - (Student 12)

“I see what you’re saying, but I mean, privacy is always a concern and installing cameras anywhere… you really increase the risk of someone hacking into those cameras and seeing the location of maybe certain students or, if anyone’s – how many people are in a building at a certain time, or just violating privacy in general.” - (Student 13)

Students also overwhelmingly discussed training systems with biased data that would ultimately provide inaccurate predictions and identifications and misidentify groups of individuals. Students highlighted that these concerns specifically did not have an immediate fix.

“So, say someone gets identified and they haven’t entered information in the app – what if we identify the wrong person?” - (Student 14)

“And with the technology, it’s less effective for anybody that’s not a white male. So for a college with lots of diversity, I don’t think it’s best for us.” - (Student 13)

A few recommendations about checks and balances arose through the discussion to ensure fairness and transparency throughout any selected system. These were aimed both at the

FRT but were discussed as underlying concepts for any technology on campus. Data misuse was frequently discussed among these controls but providing the community with an understanding of who had their data, how long it would be stored, and what decisions it would be used to make were recommended frequently.

“The main thing is that when the students’ health is monitored and tracked on this app, it will only be stored for 14 days, and that is also the only time that COVID can be tracked and traced, up to 14 days. So after 14 days, I plan to discard all of the health records of all of the students in order to keep complete safety of their privacy.” - (Student 2)

“[Your data] should only be shared if you’re around somebody that reports that they might not feel good that day or were in contact with someone who tested positive.” - (Student 15)

“I just think as an administration, we’ll do the best we can to present and be transparent with the student body regarding our decision.” - (Student 16)

“I think some issues that we’re going to run into there is one, you have to make sure you’re completely open and transparent with any data and any new findings that come from the app.” - (Student 17)

6. Discussion

The role-play scenario developed for this study allowed students to explore a timely topic and delve into overarching concepts of privacy, fairness, bias, and equity in an algorithmically supported everyday system. The facial recognition scenario was developed in early 2020, and as students participated in the RPS activity, they would occasionally catch themselves talking about the scenario out of their assigned character. While some of this may be attributed to their inexperience with role-play activities, exploring how FRT would affect student life for the whole community resonated with the participants. They had a deep and personal connection to the case because it resembled a realistic situation that could potentially happen to them outside of the RPS activity. At the time of participating in the RPSs, there was an active discussion among institutions on measures that could be brought to campuses to ensure a safe return. Students were keenly concerned with how FRT or other adjacent systems would affect them if they were introduced to their own campus.

The RPS successfully encouraged students to navigate different perspectives through the case discussion. Each role was created with detailed personal and professional information for each persona, including their academic background, current employment, position on the use of

technological problem solving, and their perspective on the use of the current mobile application. In addition, the roles were designed with narrative spaces that allowed each participant to fill in based on their unique perspective of the role. Participants also used the resources provided to fill these gaps, as can be seen by the references to misidentified and faulty data referenced throughout several of the quotes. This was an example of students successfully bridging the resources provided before discussing the activity in talking about the case.

There were some parts of the case that students wanted to talk about, but the lack of specific information caused more doubt. The cost of implementing the FRT system was one such detail, which was not explicitly outlined in the case. Keeping this information open-ended was a narrative choice, although students were exposed to the cost of these kinds of systems through the resources provided before the activity. Some students focused on how expensive and currently unavailable such an advanced FRT system would be. Students mostly argued against using FRT because there were alternatives that could provide similar results without the high cost. However, others referenced the overall cost of the pandemic and that, in comparison, paying for an FRT system would be a justifiable investment. Ultimately, students could navigate the lack of information by filling in the gaps and independently conducting research.

7. Conclusion

This study aimed to explore how first-year engineering students identified and discussed the implementation of facial recognition technology in an everyday space. The case that we developed explored a scenario that could potentially occur to the participants due to the recency of the case. Additionally, students overall need to understand algorithmic decision-making systems due to the likelihood that they will be involved in the process of working with these types of systems. Through the analyzed discourse from the student's RPS activity, participants were able to identify a wide breadth of ethical issues, negotiate between different stakeholders in the activity, and work towards a consensus that took into consideration the layers of detail at play.

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Appendix A: Role-Play Scenario – Case Study

Facial Recognition for COVID Detection and Prevention at Andrew Hamilton University (AHU)

Trisha Brown is the Chief of Safety and Emergency Management (SEM) office at a large suburban university, the Andrew Hamilton University (AHU). She is responsible for the safety and security of all students, faculty, and staff on campus. In recent months, her responsibilities have suddenly shifted from the regular aspects of the work – the police force, traffic safety, fire drills – towards responding to the needs of keeping the university functional and safe during a pandemic. She and members of her office have been working round the clock to ensure that the campus is ready to open for the new semester.

While they work towards this goal, she is also engaged in planning for the future of the campus and as part of this effort, she is looking at technology solutions for the problem at hand. She has to be prepared, she has realized, for the eventuality that a vaccine will take some time to develop, and even if it does, it might not be as effective as it needs to be, and not everyone might agree to be vaccinated. She has assembled a task force with members from across the university and has worked hard to ensure that all constituents are well represented. On the recommendation of this task force, to keep the decision-makers informed and to be able to track the health of anyone who is on campus, she has championed an app where users can upload their health information daily.

One member of this task force, a staff member of the Information Technology Software and Services (ITSS) group has recently approached her with another innovative technology that can address one of the shortcomings of the app, which is that users have to proactively submit their information and there is no way to capture their health automatically. Even though the university is thinking of taking people's temperature as they enter buildings, this approach will require manpower and it might be too late if someone has been on campus for a while already and interacted with others. The new technology uses facial recognition to identify if someone is on campus and then quickly looks them up in the app database to map if they have entered their information. If not, they get a notification on their phone, and security is alerted to their presence and where they are on campus.

Although Trisha is appreciative of the power and possible usefulness of this technology, she is a little circumspect of the privacy, bias, and discrimination issues that she has read about. For instance, she is unsure how to balance the pros and cons of this solution especially since facial recognition technology and solutions for analysis are changing fast. She knows that a lot of parameters must be looked at and examined in-depth if a good solution must be reached regarding the usefulness of this potential solution. Consequently, she has asked her task force members to learn more about the use of facial recognition and then report back to her with their personnel recommendations about this solution and she has further instructed the task force to reach a consensus on their recommendation so that she can forwards with making this decision.

Each of you has been assigned one of these roles as members of Trisha's task force and today you are meeting to present your personal recommendation and why you suggest that and then discuss as a team to come towards some kind of consensus on your recommendation to Trisha.

Appendix B: Role-Play Scenario – Participant Roles

Steve Smith is a Vice President in the Information Technology Software and Services (ITSS) group at AHU and has recently moved to AHU after a successful career in the industry. In his last job as Chief Technology Officer (CTO) of a small company he successfully led the migration of their legacy software to a cloud-based solution and is an unabashed technology optimist who believes that I.T. can solve almost any organizational problem and that once a solution has been implemented any problems associated with it can be addressed. No new technology, he is quick to point out, comes without some downsides that must be overcome.

Courtney Jones is an undergraduate student in organizational psychology and the vice-president of the AHU student organization. As part of her position, and because of her interest in the wellness and wellbeing of fellow students, she represents the student body on this task force. Courtney is a frequent user of social media and has used it well to drum up support for causes that she believes in on-campus and she has been vocal about the safety of women on campus and around the campus. She had recently launched a major campaign against bullying on social media and had also campaigned for the COVID app when it launched.

Trevor Jackson is a professor in the Department of History and a member of the faculty senate. He represents faculty on this task force, is dedicated to AHU, and serves on many other committees as well. As a historian, he often takes a long-term perspective on issues and is often circumspect of technology-based solutions especially when he thinks there are other, and in his opinion simpler, ways of solving a problem. When the app for COVID was being rolled out, he was the one who pushed for self-reported data entry by the user rather than some form of automatic collection of information. He is often preoccupied with issues of surveillance and new limits on privacy due to technology.

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