Ethics in Engineering Education Using Virtual Worlds

Dr. Jodi Reeves, National University

Dr. Jodi Reeves is an associate professor in the Department of Applied Engineering at National University in San Diego, CA. She teaches courses in design engineering, engineering management, electric circuits, and other applied engineering courses. She is also the lead faculty for the Data Analytics program in the School of Engineering, Technology, and Media at National University. Prior to academia, she worked for almost ten years as a quality control manager, engineering project manager, and senior scientist responsible for failure analysis of thin film materials. She also managed collaborations with national laboratories, Air Force and Navy research groups, and universities. She invented new quality control tools and supervised interns from local universities and community colleges as part of a $5.0 million technical workforce development initiative funded by New York State. She has published diverse articles on topics ranging from engineering education to high temperature superconductors and has spoken at many national and international conferences. Her doctorate in materials science and engineering are from the University of Wisconsin, Madison, and she has four patents issued and one patent pending.

Dr. Larysa Nadolny, Iowa State University

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Abstract

Ethical decision-making is key to the development of future engineers in our global and diverse society. The use of virtual worlds in Science, Technology, Engineering, and Math (STEM) education is an innovative use of technology in the classroom. This paper will describe how we developed, deployed, and assessed a novel approach to engineering ethics education that uses virtual worlds to teach ethics in STEM classes. Our project, SciEthics Interactive, is a 3-D virtual world where students take on various scientific roles and produce engineering reports in a hypothetical company producing genetically modified salmon. In this study, non-traditional students in both on-line and on-site classes participated in piloting this virtual world. Throughout their role-playing activities, different ethical dilemmas appeared. After the activity, student feedback was collected in the form of a survey, which will be used to further refine and improve the SciEthics virtual world and expand its use in teaching ethics as part of STEM curriculum.

Key Words: Ethics, STEM, virtual worlds

Introduction

Too often engineers and scientists think of ethics as something pedagogical rather than practical. Many college courses frequently do not discuss ethical issues in Science, Technology, Engineering, and Math (STEM) at all, and any course activities are frequently centered on case studies[1-6]. But analyzing case studies is a passive activity, done by students who are removed from the real-life situation. We wanted to investigate the use of ethical dilemmas in a virtual world to see if students learned, and enjoyed learning, about ethics in this new format.

Three-dimensional virtual worlds can provide students with opportunities for exploration and learning that would not otherwise be possible in traditional classroom settings. They are simulated environments where the student can move through a three-dimensional, navigable and persistent space[7]. Virtual worlds centered on the STEM fields are particularly powerful, as learners can immerse themselves in content too big, too far away, or too dangerous for the classroom[8]. Subsequent reviews of research in the educational use of virtual environments indicated positive outcomes with student motivation, learning, and social behaviors[9,10].

The goal of the SciEthics project is to increase the ethical engagement and content knowledge of STEM students within a virtual environment. The virtual simulations represent real-life situations that engineers and scientists face in industry, and measure student responses to various ethical dilemmas that they are faced within their simulated role. This research study examined the student experience and learning in a virtual science and ethics activity in two engineering management courses in two different course delivery formats.

SciEthics Interactive Project Design

To simulate a real-life industrial situation, we built a hypothetical company TransGen that is producing genetically modified (i.e. transgenic) salmon. The students join the company as a new employee on their first day of work and are provided one of three roles in the virtual world: 1) scientist, 2) activist, or 3) government regulations agency member. Through an instructional handout, the students are introduced to the challenge ahead.

> *Your report is a very important part of your job as a researcher/activist/regulator. The public puts a great deal of trust in you – and your ability to look out for their best interests. You need to determine the risks and rewards of Genetically Modified Organism (GMO) salmon grown at TransGen. Your report will help determine if these fish should be approved for human consumption.*

Each role has a checklist of things to do on their first day; the overall checklist is the same but what might happen in certain steps is different depending on the role. All students go through the orientation maze, visit the GMO museum to take notes on the slides and take a quiz, then go to the main building to start the day. The next steps include checking in with the receptionist, visiting the locker room, getting dressed, and checking email in the office. Throughout the day they visit different places on the island: the laboratory where data is taken, the salmon holding pens, and the cafeteria for lunch. At the end of the day the employee goes to their remote office to check email and then follows a path of questions to finish the activity and exit the island.

After the activity, the student must create a report to recommend if these GMO salmon should be approved for human consumption. To guide the students to their recommendation, a series of questions were provided. For example, the activist was asked to include the following information in the report:

1. Provide general information. What is the advantage to the production of this GMO?
2. Identify the intended use and consumer.
3. Describe the method of distribution and storage.
4. Describe the data supporting the claim of the GMO product.
5. Identify potential process and species- related hazards.
6. Considerations of the GMO and/or its product for human health.
7. Potential environmental impact of the product.
8. Overall recommendation. Does the benefit of this product exceed the risk?

The questions for the researcher and regulator were similar, with a few unique questions and ethical dilemmas added. For example, the researcher also has to create a report based on growth data taken on regular salmon and GMO salmon. What the researcher finds while taking data on different fish samples at various stages of growth is that there is not a big difference between the

growth rate of regular and GMO salmon. However, the boss has emailed the researcher earlier that day to emphasize that company needs to show that GMO salmon are better because they grow faster than regular fish. Should the researcher modify the data report to make the boss happy, especially when the boss mentioned in the email that the last researcher was no longer with the company because their reports were not following the company standard? Another ethical dilemma is encountered when the student notices that the pen where the GMO salmon are kept has a hole, which might have allowed GMO salmon to escape in the wild. The company assures you that no modified salmon have escaped, and it would really make the company look bad if news of this were publicized. Should you keep quiet to keep your job?

After completing the virtual portion of the activity individually, the students then participate in a large group discussion with the course instructor on ethical issues in STEM.

SciEthics Interactive Project Implementation

Traditionally our Engineering Management (ENM) 604 course includes a chapter on ethics from the textbook. Case studies are used to supplement the textbook information and include research, analysis, and reporting on the Challenger explosion in 1986, the Hyatt Regency walkway collapse in 1981, and the Ford Pinto fires in the early 1970s[6].

In 2011-2012 we added the SciEthics activity to two ENM 604 sections. All students enrolled in the course were invited to participate in the study and only three students did not participate. One class was offered on-line (n=16) and the other class was offered on-campus (n=14). The majority of the students in each class are non-traditional STEM students with an average age of 38 years old. The student population is mostly male (83%), English as a primary language (70%), and with many military veterans in both sections (30-40%).

To begin the activity, students were given handouts on how to enter the virtual world, create an avatar, and began the activity during class time. On their own time over the course of a week, the students were to follow the instructions on the handout to complete their first day duties as a new researcher or activist or regulator. During the next class session, students were given time to ask questions about the activity or questions about their final report. After the report was turned in, the instructor led a group discussion about SciEthics and what the students learned about genetically modified salmon and the ethical dilemmas the student faced in their different roles.

The three roles were evenly divided among students in the class. Students spent an average of four hours exploring TransGen Island. Students were asked to complete a 16-question survey after the completion of the virtual world activity including questions on the virtual experience, beliefs in science and ethics, and feedback for the instructional designers. Survey questions included open-response, yes/no, and 4 and 5 point Likert scale items. The survey results were analyzed using descriptive statistics as well as Pearson's Correlation to indicate relationships

between survey questions and mode of course delivery. We collected additional information from students in the form of a student self-reflection as an extra credit assignment after the activity was completed and the final report turned in.

Results and Discussion

The students in both courses were overwhelmingly positive about the educational value of this activity, with only 10% indicating that the activity was "not at all worthwhile" (Figure 1). The majority of comments from both on-site and on-line students are similar to what this student wrote, "Professor, I actually enjoyed it, much. I did get frustrated at some stages, but I was sure to note it inside the system for any evaluators. It was a forward thinking experiment - and I can appreciate that." Even with two different delivery methods, the on-site and on-line students did not have any significant differences in responses to the survey questions.

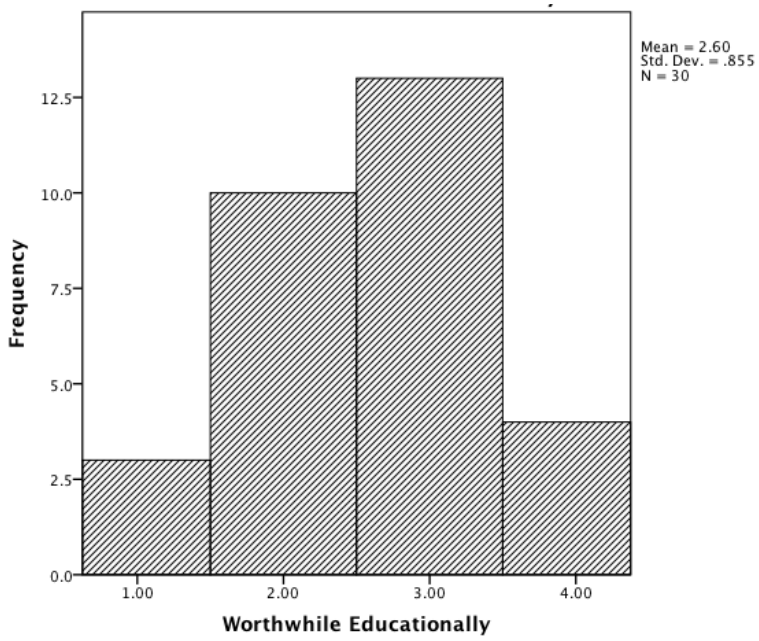

Figure 1: This exercise has been worthwhile from an educational standpoint.
1= Not at all worthwhile, 2= Slightly worthwhile, 3= Worthwhile, 4= Very worthwhile

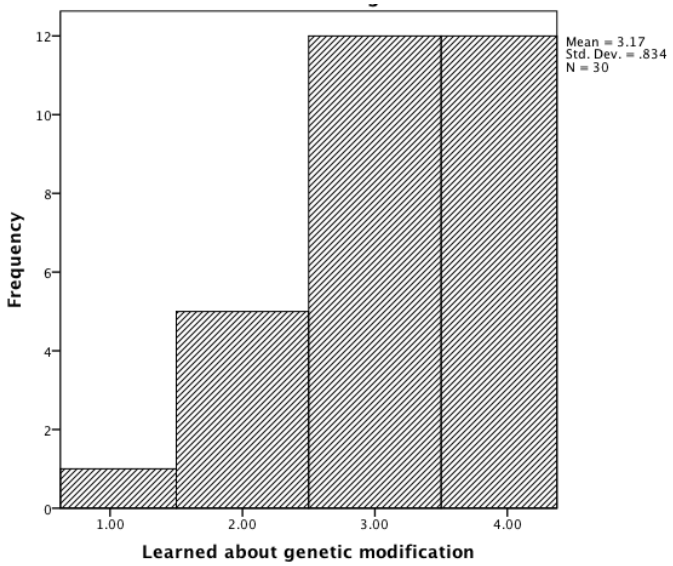

Figure 2: I learned something scientifically valuable about genetic modification. 1= Nothing, 2= A little, 3= Some, 4= A lot

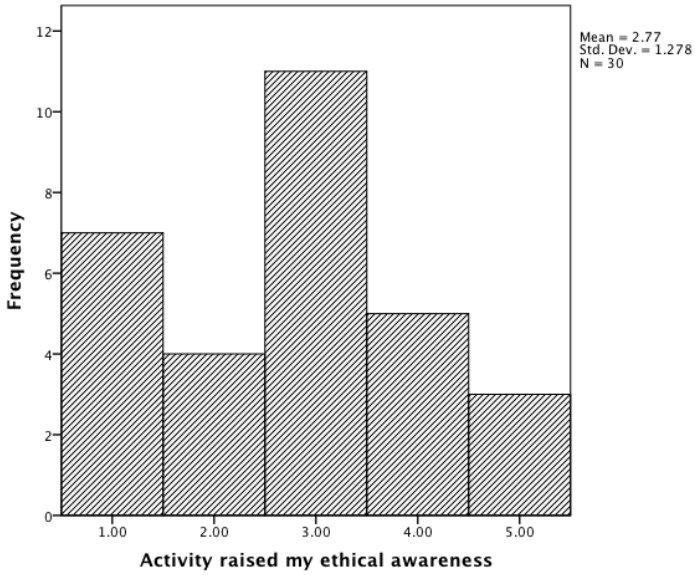

Figure 3: This exercise raised my awareness of ethical issues around this research. 1= Did not raise my awareness, 2= Raised my awareness slightly, 3= Raised my awareness somewhat, 4= Raised my awareness significantly

The primary goal of the project is to impact science learning and ethical awareness in students enrolled in STEM courses. That goal was achieved in science content, as the majority of students reported "some" or "a lot" of learning about genetic modification (Figure 2). Changes in ethical awareness were not as strong (Figure 3) after the virtual activity. Although the online portion of the activity did not have a large impact on students' ethical understandings, 50% did recognize the ethical dilemmas present on the island. One student showed an emotional connection to his assigned role and the perceived unethical behavior, by stating that the "supervisor has an agenda by assisting a close friend to look good. A hook up. Product is flawed and research is flawed and are looking to use the good name of the inspection agency to promote a bad product." Another student recognized the power struggle between supervisors and employees in data collection.

> *"Right off the bat, my supervisor informed me, that my report would make me or break me with this company and the companies future was in my hands. The last person that had my job was let go. After further emails I see that most likely it was because the previous research scientist most likely didn't approve of the findings and told the facts."*

Suggestions for improvement were also solicited from students who initially had some difficulties with the virtual world experience. "I struggled to operate comfortably in the virtual world and did not take full advantage of the photo and notes functions to help support my written work. I was able to get through all the required steps and locations in the virtual world; visitors center, office, locker, changing room, one of two laboratories, the hall of fame, and questionnaires. I was able to visit the cafeteria, have some interaction with displays and other characters, found and read email and folders: but I constantly felt frustrated and allowed this to distract me from the information I would need to submit my final report. I was comfortable that I was able to check off nearly all of the encounters that were laid out in the exercise guide sheet but, I felt that I had somehow, somewhere, missed some key stops," wrote one student.

Interesting student feedback was received from the non-traditional students who are typically over age 30 and from military veterans. One student over the age of 30 wrote, "I believe the SciEthics definitely pushed me outside of my comfort zone, which is something that I should expect when I am involved in higher education. I now realize the importance of taking on challenges that do not necessarily have importance "in the moment" but are intended to open me up to new experiences. These experiences add to my collective experience in spite of the discomfort that create in process."

Another student, a military veteran, wrote, "My situational awareness was low during the exercise. I was not clear on how to do the work or what the outcome was intended to be. In short I felt awkward throughout the exercise. In hindsight, I recommend that future classes spend some "supervised" time in the simulation under your guidance. Students need to have

some training in moving around and in the overall intent of the evolution. It was an educational experience for me! I see potential with this modality."

Therefore, the feedback for improvement showed how technically the virtual world could be improved but also caused the SciEthics developers to think about the virtual world from a different perspective. Most traditional students of age 18-25 have grown up with the Internet, social media, and gaming. But non-traditional students at our university did not have much experience with gaming and so were not initially very receptive to SciEthics when it was introduced in class. One student in the on-line class reflected, "The experiment took me nearly two days to complete, as I have never experienced a virtual case study before and had to learn everything a child with a X-Box would likely already know by age 6. There was much to learn, and I thought the entire process could be streamlined - yet the way the program allows one to morph their avatar into resembling them is interesting - as I know what several classmates look like from pictures, and they seemed to align with their cartoonish avatar rapidly. Some (my buddies for the capstone) even invited me to meet up and kick back!"

Conclusions and Future Work

SciEthics, a virtual world activity where students take on a role in a fictitious company experimenting with genetically modified salmon, was used to supplement ethics content from textbook reading and case study analysis in two engineering management classes at our university. The survey results indicated that most students were positive about learning ethics in this format, enjoying this project in the virtual world, and recommending it again in the other classes. Qualitative student feedback will be used to further refine and improve the SciEthics virtual world and expand its use in teaching ethics as part of STEM classes in the future. Additional modules, such as Rainforest Island, are being created to give students experience in other virtual worlds to explore topics such as green technology and sustainability. This first SciEthics simulation, TransGen Island, has been released to the general public and can be downloaded at www.sciethicsinteractive.com. For use in a class, the website includes a faculty guide, student handouts, and introductory videos to help new faculty and students get started.

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