Pedagogy of Engagement: Exploring Three Methods in an Engineering Ethics and Professionalism Course

Jessica Wolf, University of British Columbia

Jessica Wolf is a PhD student in the Department of Mechanical Engineering at UBC. Her research focuses on equity issues in engineering education, particularly looking at the impacts of engineering outreach programs on historically marginalized groups in STEM.

Gayatri Gopalan, University of British Columbia

Gayatri Gopalan is a PhD student in the Department of Curriculum and Pedagogy in the Faculty of Education at the University of British Columbia. Her research interests lie in exploring questions of critical pedagogical and educational responsibility within dominant neoliberal, increasingly neoconservative, and (post/de)colonial discourses that frame curriculum and teaching practices.

Dr. Christoph Johannes Sielmann P.Eng., University of British Columbia

Dr. Sielmann is an Assistant Professor of Teaching at the University of British Columbia in the Department of Mechanical Engineering supporting both Mechatronics and Manufacturing Engineering programs. His research interests including multi-campus instruction, decolonization in engineering, and engineering ethics.

Pedagogy of Engagement: Exploring Three Methods in an Engineering Ethics and Professionalism Course

Abstract

This paper explores the role of three pedagogical interventions in engineering students' learning about ethical and professional conduct, with a particular focus on affective engagement. Many transformative efforts involving equity, diversity, inclusion, and decolonization are centered on ethics as a justifying principle, which further stresses the need to cultivate an ethical orientation in engineering practice, beyond specific knowledge. A new course on professionalism and ethics was introduced as a platform to explore scalable pedagogical approaches to enhance engagement and achieve affective learning outcomes in engineering ethics. The learning activities were designed to stimulate critical thinking about social aspects of engineering and to reframe the traditionally technical obligations of the engineer within sociopolitical and equity-oriented structures.

Through a qualitative analysis of student experiences, assignments, and reflections as part of the course, this paper evaluates the impact of three pedagogical methods on student engagement with ethical questions surrounding their decision-making as both individuals and as future engineers. The three methods being studied are Virtue Points, a tool that encourages self-reflection by contrasting personal and professional virtues, an adapted 'Spectrum Game' based on concepts presented by Jubilee Media, and a modified Pisces Game used to explore Tragedy of the Commons. Early findings show positive engagement with both the Pisces Game and Spectrum Game, with many students describing these two as particularly impactful and enjoyable. Virtue Points yielded results that surprised many students, and there are indications that clarifying and amending the scoring system for the game may promote better understanding of how it can support self-reflection on virtues.

Introduction

Ethics education in undergraduate engineering programs has long been a source of struggle for engineering educators [1]. The need for ethics education in engineering in Canada is driven by Engineers Canada through the Canadian Engineering Accreditation Board to promote adherence to the Washington Accords and encourage high quality engineering education of Canadian students. However, the interpretation of the Codes of Ethics as a list of rules to avoid breaking, as well as the pervasive technocratic and utilitarian ideologies within the culture of engineering, have led to ethics being often taught in a prescriptive way that fails to encourage students to consider the intersection of their technical practice and their sociopolitical impacts [2], [3], [4]. Although the EGBC Code of Ethics requires that engineers "hold paramount the safety, health, and welfare of the public" [5], studies have found that engineering students' engagement and prioritization of ethics and equity decreases over the course of their degree programs [3].

Many engineering educators have documented obstacles in teaching ethics, equity, diversity, and inclusion (EDI) to engineering students, highlighting student perceptions of these topics as unimportant to, and separate from, "real" engineering; institutional obstacles such as lack of training on teaching ethics; and students' lack of emotional engagement with ethics [3], [4], [6], [7], [8]. Researchers have suggested that there is still a disproportionate focus on "micro-ethics" and the actions of engineers as individual players, whereas we should be prioritizing discourse of macro-ethics, or engagement with ethics on a broader level, institutionally and societally [2], [4]. Gunckel and Tolbert argue that, in order for engineers to be able to solve the world's most

pressing problems (e.g. climate change), as many engineering educators hope for, they must be trained to consider the sociopolitical dimensions of such problems [2]. As Cech similarly argues, the dominant ideologies of depoliticization, meritocracy, and techno-social dualism actively work against this goal by reinforcing the idea that every problem can be solved with purely technical solutions [3].

Existing pedagogical attempts at overcoming this problem have primarily focused on increasing students' affective or emotional engagement with ethics to bolster interest and promote lifelong learning, and their engagement in general with learning ethics, e.g. with gamification, discussion, and case studies [7], [9], [10], [11], [12]. In our institution, we piloted a course on engineering ethics and professionalism that aims to effectively use scalable pedagogical approaches to increase student engagement to achieve affective learning outcomes. The course's learning activities were designed to stimulate critical thinking about social aspects and impacts of engineering, particularly regarding sustainability, equity, diversity, inclusion, and decolonization.

This is an evidence-based practice paper that describes the innovative pedagogical methods of a new fourth-year engineering course on ethics and professionalism, and students' perceptions of and engagement with ethics through these activities. The first iteration of the course was mandatory for one small engineering program and optional (with a different, more traditionally taught ethics and professionalism course as the other option) for one large engineering program. There were 44 students enrolled, and enrollment is expected to increase in subsequent years, necessitating scalable practices.

The three pedagogical methods discussed in this paper are: (i) a new Virtue Points tool that encourages self-reflection by contrasting personal and professional virtues [13], [14], (ii) an adapted Spectrum Game based on concepts presented by Jubilee Media [15], and (iii) a modified Pisces Game used to explore the concept of the Tragedy of the Commons [9]. Each activity was created and/or adapted to suit an engineering student audience by linking at least one sociopolitical or ethical concept to engineering while encouraging growth beyond a strictly technocratic or utilitarian mindset. These activities formed part of the 23 interactive tutorials delivered in the course.

This paper explores student perceptions (with a focus on affective engagement) of the three pedagogical methods employed in the course to evaluate the role of these methods in students' learning of ethical and professional conduct. The research questions that inform this study are:

1. Did the three examined activities effectively promote students' affective engagement with the material?
2. Does the modified Pisces Game encourage a diversity of approaches and opportunities for ethical learning among engineering students?
3. Were the Virtue Points and/or the Spectrum Game effective at encouraging student self-reflection?
4. Did the Spectrum Game help otherwise quiet engineering students to share their perspectives with others?

Methodology

This study employs an interpretivist paradigm that prioritizes understanding students' experiences in their own words through qualitative methods. The principal investigator of this study (CS) was the instructor of the course, and the other two authors (JW, GG) were teaching

assistants (TAs). CS and JW jointly developed the course content and learning activities, and CS and GG had most of the student contact during the course, as the lecturer and a tutorial facilitator, respectively. JW coordinated the tutorials and teaching assistant facilitation during the course term, graded some student work, and gave a guest lecture. While there was a lecture component to the course, most of the activities, including the modified Pisces Game and the Spectrum Game, were conducted during the tutorials.

The data used in this study were student work from the course and JW's notes from weekly teaching assistant meetings in which the past week's tutorials and student engagement were regularly discussed. The student work used in the analysis came from a variety of submitted assignments. The student work was primarily responses to reflective questions based on their experiences in tutorials and with the three pedagogical methods employed in the tutorials. The student responses included multiple choice, open-ended response, and a final reflective essay. Multiple choice and open-ended responses were primarily derived from weekly submissions of students throughout the course that correlated with the themes discussed during each week of the course. The final reflective essay encouraged students to reflect on the course and their learning in the form of a 1500–2500-word essay addressing a series of prompts about

(i) the engineering profession (e.g. - '*In light of upcoming challenges to humankind and biodiversity, do you think that the role of engineering, or the meaning of "engineer" or "professional", should change in the future?'*);
(ii) their ethical positionality (e.g. - '*How do you see equity, diversity, and inclusion intersecting with engineering, both in general, and in your personal life/career?*');
(iii) course learning (e.g. - '*How did this course change the way you think about your role as an engineer, considering technical, social, and environmental aspects of the role?*);
(iv) course content (e.g. - '*Which two tutorial activities did you find most personally impactful and why? Which were least impactful?*'); and
(v) personal reflection (e.g. - '*Do you think your "virtue point" scores from the course are reflective of your personal virtues and values as an engineer?*').

Most of the assignments included were graded based on effort and/or depth of reflection, which may have influenced their responses.

Questions posed to the students encouraged constructive feedback (both positive and negative) by asking about, for example, the most and least impactful tutorial activities. For the purposes of the research, all student responses—whether positive, negative, or any other—were considered as being part of the affective landscape of engagement for students. All mentions of each intervention, both positive and negative, were coded and used in thematic analysis.

Following ethics board approval (REB #H23-03156), responses were de-identified and inductively coded by CS to conduct a thematic analysis. The first pass of coding included simultaneous methods of attribute coding, structural coding, and emotion coding to organize the data [16]. Categories and initial themes were developed and discussed by the authors, with a second pass conducted to refine support themes and categories. To improve accountability, all three authors discussed the codes, categories, and themes at multiple stages of the analysis process.

Interventions

Virtue Points

A valuable yet often under-represented ethical framework in engineering is virtue ethics. Aristotelian Virtue Ethics is considered one of the three traditional "pillar" frameworks along with deontology and utilitarianism for ethical engineering practice [17]. Practicing virtue ethics involves taking regular and intentional actions aligned with specific virtues for the purpose of building good habits. An important benefit of leveraging virtue ethics within engineering education is that it allows a serious, individualized, and positive treatment of ethics that encourages students to be "more good" instead of "less bad" [13], [18]. A scalable, automated, personal, and gamified pedagogical approach was sought that would draw students' attention to engineering virtues, allow them to compare their own virtue strengths and weaknesses to their peers (the mean), and serve as data for self-reflection and targeted self-improvement.

Virtue Points was a novel intervention introduced to track student decisions and self-reflections through a virtue ethics lens throughout the course. Drawing heavily from the course's self-professed intent to encourage and prioritize virtue ethics, the following virtues were considered in the calculation of Virtue Points:

1. Care
2. Compassion/Empathy
3. Objectivity/Perspective
4. Fairness/Justice
5. Honesty
6. Prudence
7. Courage

Each of the virtues and virtue pairs listed above were identified as significant to the conception of an ethical/good engineer [13], [19], [20]. Virtue Points were calculated based on reflective survey questions throughout the course, where student responses to multiple choice questions were attributed specific points that contributed to their Virtue Point totals, as well as through peer review and assignments. Questions were phrased to assess student alignment with specific virtues given a short case study or position. For example, students were asked whether they feel strongest alignment with "It's wrong to use people", "I appreciate when others correct me", "It is important to me to be open and honest about my feelings", or "Having a warm and generous affect seems to bring reassurance and joy to others." Their choice would give them a point in Fairness/Justice, Care, Honesty, or Compassion/Empathy, respectively.

Software developed in Python was used to calculate scores based on assessment results, with points updated weekly. These Virtue Points were not part of the summative evaluation for the course and were used during the modified Pisces Game and as prompts for student self-reflection in the final essay. Students could track their Virtue Points throughout the course on Canvas, a learning management system (LMS) used by the course. At the end of the course, students were specifically asked to reflect on their Virtue Points as a window to self-understanding and personal capacity for ethical practices.

Students were encouraged not to view Virtue Points in absolute terms, but to consider their score in the context of the classroom, allowing them to compare their personal prioritization of

particular virtues against the norms established by their peers. Although not intended to be very accurate given the limited number of assessments involved, Virtue Points were intended to serve as a source of reflection that would encourage students to regularly challenge their personal bias and encourage a deeper understanding of the values present in their engineering community.

Spectrum Game

On topics of significant controversy, it can be difficult to encourage quiet or under-represented students to speak out. In many group activities oriented around engagement, such as think/pair/share, students can still "opt out" by contributing little of personal significance to the discussion, meaning that they risk little, and their voice is not heard. Substantive discussions around topics such as EDI are often difficult for this reason, as many students are prone to avoiding controversy. Despite these challenges in engagement, peer learning is a remarkably effective mechanism for both cognitive and affective learning [21]. When addressing topics related to EDI, we sought a way to encourage all students in the classroom to "speak", even if not out loud.

The Spectrum Game activity was inspired by Jubilee Media's 'Spectrum' game on their Youtube channel (Youtube handle - @jubilee) [15]. In this game, the floor space is divided into six columns using duct tape to signify a spectrum of six opinions from 'Agree' to 'Disagree'—Strongly Agree, Agree, Somewhat Agree, Somewhat Disagree, Disagree, Strongly Disagree—as shown in Figure 1. Each line represents an opinion threshold, like a human-sized Likert scale.

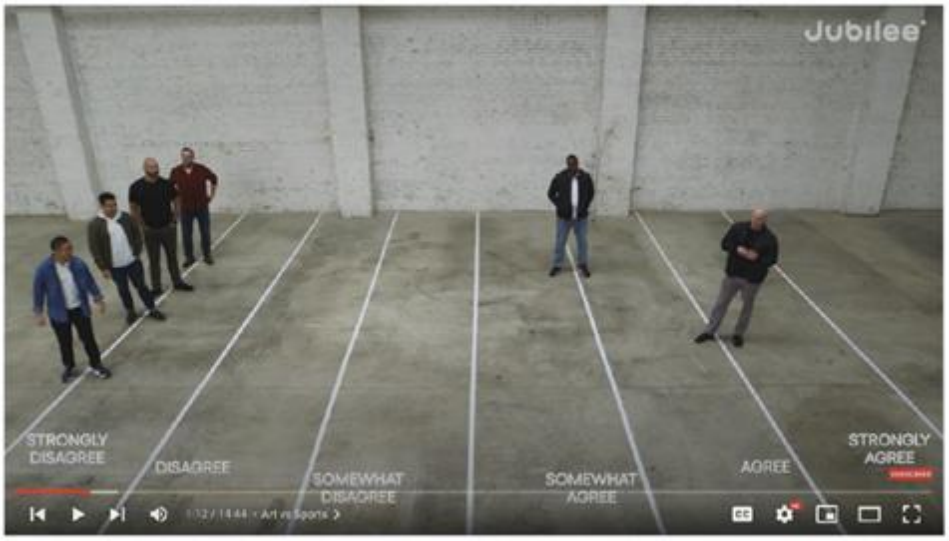

Figure 1: Spectrum Game configuration (as shown from Jubilee Media)

As the game begins, all participants line up at the center of the room. A general opinion statement is shared by the moderator, and participants move towards a particular line representing the degree of their agreement (or disagreement) with it. Once all participants have signified their opinion by physically moving to the space, the floor is opened for discussion where each participant justifies their stand. At the end, participants are free to change their position if their opinion is altered by others' arguments.

For this activity, given the physical limitations of the classroom space, the spectrum of six opinions was set up in different areas of the classroom, and students were asked to begin from a neutral starting point. A set of statements were chosen with the intention of sparking thinking around questions of power and privilege. The following statements were employed in this activity, with statements 1-10 used in the initial tutorial that had this activity, and statements 11-19 used in a later tutorial with the same activity format.

1. Humans are inherently selfish.
2. I think competition brings out the best in people.
3. Profit and ethics are opposing motives.
4. Anyone can be successful if they work hard enough.
5. I am obligated to give to the less fortunate.
6. I worked hard for everything I have.
7. I live a privileged life.
8. My identity (e.g. race, gender, class, ability) prevents me from engaging with others the way I want to.
9. I am proud of some aspect of my identity.
10. I felt social pressure to lie about at least one of my answers in this activity.
11. Some of my actions are perceived differently than the same actions of others who are members of a different group/identity.
12. I am aware of instances when I am the only person of my identity in a room.
13. Focusing on race divides us.
14. Some racial stereotypes are accurate.
15. Asian people have it easier than other minorities.
16. Men and women are inherently different.
17. Male privilege is real.
18. Toxic masculinity is overblown.
19. I believe engineering is more masculine than the arts.

These statements were chosen by the course development team to reflect potentially controversial questions related to positionality and EDI themes. The objective was to prompt discussion around topics on which some students may have strong emotional engagement yet are not often discussed among peers.

After the TA read out an introductory statement, students moved to the corner that best represented their opinion. They also observed the corners chosen by their peers. A discussion followed, during which students were given the opportunity to explain their choices. Students were also free to change their stance based on the discussion and arguments put forth by their peers. After the discussion, students would return to the starting point, and the next statement would be shared. This activity was of one hour in duration, with 5-10 minutes dedicated to each statement and its discussion.

Modified Pisces Game

Gamification is an important part of the pedagogy in the course, where critical lessons are reinforced through game-like activities. Games, especially with numerically driven strategies, are by their nature engaging to engineering students when properly executed. Students who "get into" the game show strong affective learning and are more willing to invest themselves into the activity [22]. The Pisces Game is a game developed by Spierre, *et al*. that introduces the concept

of the Tragedy of the Commons [9], [10]. This game is conceived as a fishing experience where participants are members of villages harvesting fish from a common lake for survival. Spierre, *et al*. describe the premise as follows [9]:

> Each group represents a village of fishermen and all the villages are fishing from a shared common lake to survive. Each village has a single fishing boat (with limited carrying capacity) and on each turn, can harvest fish from a common lake. Villages must harvest enough fish in each round to survive (four per person). Any extra fish may be used as capital to build a private fish pond, stock their private pond with fish; or share their fish with other groups… At the end of each round of play, reproduction occurs in the common lake. Reproduction increases the fish population in the lake by as much as 30%, depending upon the current fish population and carrying capacity of the lake.

While originally conceived as a random order grouping, for this course, additional rules and harvesting order were put in place based on the collective Virtue Points of each group. The groups used for the game were the same groups that had been formed at the beginning of the term. The Virtue Points based modifications were as follows and were intended to add more continuity and game-elements to the course:

1. Prudence: The sum of all Prudence Virtue Points in the section influences the starting number of fish in the common pool.
2. Fairness/Justice: The team with the highest amount of Fairness/Justice Virtue Points (proportional to team size) will always have an extra limit on their private pond stock—it cannot ever exceed the stock of the team with the next-highest private pond stock (e.g. if Team 1 is bound by this rule, Team 2 has 0 fish in their private pond, Team 3 has 8 fish in their private pond, and Team 4 has 4 fish in their private pond, then Team 1 cannot have more than 8 fish in their private pond).
3. Compassion/Empathy: The team with the highest amount of Compassion/Empathy Virtue Points (proportional to team size) is obligated to share at least 1 fish each round with the losing team if they have the fish to spare in their private pond.
4. Care: The teams' harvest order will follow the order of Care Virtue Points from highest (gets to harvest fish first) to lowest (last).

Up to 8 rounds were played, until the class ran out of time (60 minutes), or until only one group was left alive (people in a group died if they could not feed 4 fish per member), whichever came first.

Students were introduced to the concept of the Tragedy of the Commons, and the specifics and rules of the game prior to coming to class. The game was intended as a 60-minute exercise, and the calculations of harvesting were followed on a spreadsheet in real time during the game. The TA entered all the numbers into the spreadsheet (to which groups had prior access in order to understand the mechanics of the game) but did not show the spreadsheet to the class. For each team's turn, the only information told to the class was how many fish they claimed to have taken from the common lake (they may lie), which was to be announced after each group's turn so that the following groups had that information. The TA also announced to the class if any of the groups gave or received gifts of fish, if any of the groups were not able to keep all members alive, how many fish were left in the common lake, and the resulting reproduction rate of the common lake. The TA privately told the groups their private pond capacity and new stock after

reproduction. At the end of a round, each group could also make a quick announcement to the other groups regarding what happened in the round with the intent to influence their future actions. This was followed by a written reflection and discussion on how the game played out.

Findings

Virtue Points

A thematic analysis of student self-reflections revealed four themes related to Virtue Points. An emphasis was placed on affective and value-oriented coding of the data.

Theme 1: There was confusion about how to correctly interpret the point totals.

While some students understood that they were expected to compare their scores to the average in the classroom to assess their prioritization of certain virtues against their peers, there were two other common interpretations. Seven students misunderstood the scaling of the virtue points, believing that each virtue was scored on a consistent and comparable scale (i.e. out of 10 possible) points, with about half of those students interpreting a score of 5/10 as the "optimal" score, as it would supposedly represent the golden mean. It was not possible to achieve a value greater than 4 or 5 points for some virtues, leading to misinterpretation of the implication of receiving such a "low" score. Despite this misunderstanding, these students still reflected on why they may have received scores lower than expected.

Theme 2: Students had mixed opinions about the accuracy of the virtue ranking.

Most students agreed with some of their virtue scores and disagreed with others. In final reflections, students were inclined toward listing their scores and discussing which virtues were ranked above and below their own estimation of self. Students who received high scores in specific virtues often claimed those virtues as important to their own self-image, whereas those who ranked poorly in a virtue were generally inclined to fault the accuracy of the points assignment or simply disagree with the outcome. It should be noted that confusion surrounding the proper reading of virtue points (see Theme 1) accounted for much of the perceived lack of accuracy. For example, one student offered:

> My virtue tracker is not 100% accurate according to my moral perspective. Although I understand and know the importance of golden means for some virtues, my personal perspective on virtues of care, honesty and fairness/justice is that the more is the better rather than the golden mean. I scored the class mean for these virtues whereas I would personally be more caring, honest and just than what my virtue points suggest.

In addition to sharing opinions of the accuracy of each Virtue Point score, four students cited evidence from tutorial work in support of the accuracy of the system. These students claimed that the teams who performed well in the modified Pisces Game through community-oriented strategy behaved consistently with their high Virtue Point ranking in fairness, compassion, and empathy. The impact of integrating Virtue Points into other activities and the perception of accuracy of the Virtue Point activity is demonstrated by the following student's comment:

> I firmly believe the virtue points accurately reflect my personal beliefs. The most compelling evidence to support this assertion is the Tragedy of the Commons game. In my tutorial section,

> my team had the highest points in care, fairness, justice, compassion, and empathy. Our team played in a manner that coincides with our belief systems. Since our team had the highest care points, we got the opportunity to go first in the game. Despite having the opportunity to empty the pond, our team took a strategy to prioritize the common good … all the members of our tutorial section survived all eight rounds of the game.

Theme 3: Students found Virtue Points engaging as a prompt for reflection.

Twenty-three students expressed positive sentiment regarding their engagement with Virtue Points, describing the experience as "compelling", "fascinating", "motivational", "enjoyable", "exciting", "impactful", "surprising", "fun", and "meaningful". Those with a positive experience generally indicated a desire to continue practicing reflection around virtues in the future. Those with negative sentiments (three students) described the experience as "confusing" and expressed dissatisfaction with the accuracy of the score received.

For example, one student indicated:

> I enjoyed the focus on virtue ethics through the use of virtue points as it allowed me to compare where I think my virtues lie …

Another expressed, demonstrating how engineering students appreciate quantification and metrics:

> Having these assessments of virtue points was really exciting and meaningful to me, as they evaluated my behaviors and presented numbers which could be used for future guidelines. I will definitely keep track of ethical decisions I make and reflect as self development.

Theme 4: Virtue Points were seen as valuable, particularly as a tool for reflection.

Comments pertaining to the value of Virtue Points were primarily found in the course reflection, with value identified in how Virtue Points can help students a) learn about biases and perceptions; b) target a higher standard of performance, integrity, and public service; c) reflect on values and priorities; and d) encourage ongoing practice. Students identified that there was need to both improve practice and capacity for some virtues, while also reducing the practice of other virtues to better align with the golden mean. For example:

> While I may not actively track my "virtue points" after the course, the experience has reinforced the significance of personal values in shaping my engineering practice and character. I believe that virtues and values are essential in defining one's identity, both professionally and personally.

Eight students indicated a desire to continue reflection on virtues in engineering practice after the conclusion of their program, with comments such as:

> I would like to continue to reflect on and practice my virtues, as they are an essential aspect of personal and professional growth. It helps me reflect on my character, and these virtues can be improved over time with continuous reflection and practice.

Overall, the student experience with Virtue Points was positive, with a clear need to clarify the interpretation of the scoring system in future deliveries of the intervention. Students were primarily intellectually engaged with the tool, though some affective engagement was also demonstrated through the tool's novelty (e.g. surprising, exciting, fun). Students saw the intervention as valuable, though of questionable accuracy, and it was effective as a tool to encourage self-reflection around personal and professional virtues.

Spectrum Game

Students only mentioned the Spectrum Game when asked to rank their most impactful or least impactful tutorial experiences in the course, with the Game mentioned by 19 students. Three themes emerged from student reflection on their experience with the Game.

Theme 1: It was a universally positive experience for all participating students.

No student described the Spectrum Game as a negative experience. The experience was described as "impactful", "active", "constructive", "informative", "personal", "significant", "interesting", "unfiltered", valuable", "effective", and "enlightening". Students appreciated hearing perspectives from their peers and were able to witness and explore a diversity of sensitive topics. One student summarized their experience in the activity as follows:

> One thing that stood out to me during this tutorial was how wide a range of opinions we had in our tutorial section. A lot of the team members were heavily influenced by their different cultural and religious backgrounds when it came to ethics and morality, and we achieved a lot of informative discourse during this section. I remember when we had to disagree with the statement, "humans are inherently selfish," some team members would disagree due to believing in the goodness of humans and what their religious backgrounds had taught them. Another statement that had a wide range of ideas was "profit is inherently unethical." Two of my team members had completely opposite opinions, one stood in "strongly agree," while the other stood in "strongly disagree." From this interaction, I could see that they had completely different political views, and I actually valued the discussion that arose from these differences in my teammates' views, cultures, and beliefs, as without discourse, I wouldn't be learning anything new in these tutorials.

Another student credited the game with underscoring the importance of understanding biases in themselves and others. This student showed through their written self-reflection a progression from initial negative reactions to different perspectives in the game, to a greater awareness and understanding of their own and their peers' biases:

> As with human nature and bias, my first reaction was typically how could anyone be in any other choice? But then after hearing the other perspectives and justifications it was clear that my own opinions and life experiences have provided me with my outlook, and with all the other individuals each having their own experiences, our reactions to these nontrivial questions were bound to vary. This was impactful as it demonstrated why it is important to be aware of bias and your own influences, especially during engineering work which can affect a much larger group of individuals unlike yourself.

More broadly, the game also shed light for some students on the potential impact of their peers' perspectives on the future of engineering, as described by this student:

> Sometimes, the opinions I heard were concerning, and it made me think more about the engineering industry as a whole and what types of people are out in the field making decisions that can affect a lot of people. There are bound to be people with lots of power that don't have good morals and are able to make big changes that probably shouldn't be implemented.

Theme 2: Students were moved by their peers to change their opinion on a topic.

Despite occurring late in the course and having worked with their group mates for over two months, many students were caught off guard by the variety of positions and opinions held by their peers. The sharing of uncommon perspectives was also persuasive in this context, with six students indicating a fundamental change in opinion on a topic because of their experience with the Spectrum Game. One student indicated in their final reflection:

> I found some of the tutorials to also be very impactful in shifting my views on important philosophical topics. Specifically, the tutorial activities that involved walking to a part of the room based on your stance on a given prompt, and then discussing and debating the prompt tended to lead to significant shifts in my opinions and the opinions of others. This activity was really interesting to me because it forced people to engage and share their opinions. I also found myself changing my perspective and seeing new prompt elements from discussing with other students. I think that even though quite few people changed their stance when given the opportunity, everyone had at least some enlightenment or shift in their views.

Another student was able to thoughtfully reflect on the influence of their cultural upbringing on their values, and described how the course lectures and the Spectrum Game led the student to change their perspective. The student was also able to better understand the origins of their peers' viewpoints through this exercise:

> The most memorable question was "Do you think people can be successful if they are hardworking enough?". Most cultures encourage people to be hardworking and people are told that we can succeed if we are hardworking enough. In Chinese culture, if someone does not achieve what they want, the only possible explanation is that they are not hardworking and persistent enough. However, during lectures, [CS] taught us that if we do not achieve what we want, we are just being unlucky and we should move on. This was pretty surprising because I have been told by an advisor that getting a desired job depends on fortune, which aligned with [CS's] statement. For this question, I chose "strongly disagree" because I changed my mind and agreed with [CS] that success sometimes depends on luck, which differs totally from what I have been taught since I was young. It was pretty interesting to realize some students chose "strongly agree" and I think they probably have been educated to be hardworking since they were young due to their cultures. This tutorial activity helped me to understand people from all around the world and their cultures, which helped me become more comfortable interacting with people from different backgrounds.

Theme 3: The game allowed sharing of rarely expressed perspectives.

Five students commented that a particularly valuable component of this exercise was the requirement for all members to choose a position reflecting their opinion for each statement. In

this way, students who otherwise did not speak or share during other group activities were given a voice. For example, one student commented:

> Lacking a neutral option, we were forced to think and have uncomfortable discussions. Discussions that ensued were highly beneficial for broadening our horizons and trying new things with our teammates. These activities forced us to share our honest perspectives and have meaningful conversations.

Another shared:

> I found the second tutorial personally impactful because the way it was set up with people being able to give their answers by simply moving to a part of the room allowed for students who normally don't contribute to the discussion to express their opinions without having to speak out.

The Spectrum Game was positively received by the entire class and was very effective at revealing perspectives that were otherwise not shared through case studies and group discussions. With arguments coming from their own peers, students seemed willing to expand their perspective on each issue and even change their mind. Interestingly, students described the experience as less "formal" than group discussions, permitting the sharing of more personal truths.

Modified Pisces Game

The modified Pisces Game was primarily mentioned by students in tutorial deliverables and final reflective essays. It was a very impactful activity in the course and was often highlighted by students in their reflections and writing after participating in the tutorial. Five themes emerged from a review of sources.

Theme 1: Leaving winning conditions unspecified led to many different interpretations and strategies for how to "win" the game.

The win condition for the game was interpreted in many ways. Some teams believed winning meant a) having all the fish; b) achieving self-sufficiency with no more need of the public pond; c) prioritizing the common good; and d) lasting the longest of all teams. Depending on the win condition chosen, teams were willing to break agreements, betray other teams, give up their own resources to help other teams, or work together for a mutual goal. The following is one description of how this uncertainty influenced the student's decision making and their understanding of bias:

> After the game, we shared under what goal people/teams played the game, I had only one goal of everyone surviving by keeping most fish in the common pond and did not even think that there would be other goals. However, the game did not present a clear goal to reach. It was a shock when other teams said their goal was to make every team independently rich with resources to survive by having enough fish in their private ponds to survive without needing anything from the common pond. It was even more shocking to find that our tutorial section was the only section with no lives lost. This helped me reflect on my virtues since I have never thought I am a caring person, but it turns out I valued societal benefits over personal benefits …

Students were asked if their approach to the game would have changed if the victors received higher marks in the exercise, to which nearly all students indicated that grading would have influenced their strategy. However, the students were split on whether they would have acted more selfishly to maximize their own grades at the expense of their peers, or if they would have acted more altruistically to minimize the "loss" of grades by their fellow students.

Theme 2: Students had generally pessimistic expectations of how the game would go, with the outcome either reaffirming that pessimism or surprising the student.

Twenty students wrote that they predicted teams would not coordinate and would play selfishly to ensure their individual victory. In some games, this prediction was realized leading to a single "winner" (i.e. all other teams lost their participants). In other games, teams characterized as especially fair or caring through Virtue Points took the initiative to coordinate, support, and uplift other teams, leading to winning conditions where all teams, and the public pond, were self-sustaining. In these situations, students expressed their surprise that their peers would not act so selfishly. It should be noted that when polled, the class consistently chose the values of Hobbes over those of Rousseau, suggesting a predisposition toward believing that humans are inherently selfish and require strict laws to enact outcomes that prioritize the common good [23], [24]. This predisposition was apparent in the pessimistic bias of students and in their surprise at seeing positive outcomes prioritizing the common good in a competitive game. For example:

> My initial predictions was that most teams would adopt a selfish approach initially and strive for the survival of their own team as priority. This sequence of event did occur at the start but I also predicted some teams to run out of resources in the process which did not happen. This was largely due to the first team's generosity and compassion as despite the greedy demands from our team, they still prioritized survival of the tutorial section as a whole and decided to play around this selfishness when they could have clearly turned the game in their favor at any point.

In tutorial sections where the game's outcomes reaffirmed the students' pessimistic expectations, students were still able to reflect on this and connect it to the broader themes of the course, as this student demonstrated:

> In my tutorial group, the game concluded rather quickly, with most teams running out of food and the fish pond being depleted. I found the outcome to be ironic, as I had assumed that engineers would excel in collaboration and achieving optimal/utilitarian outcomes. However, this was not the case, and it reminded me of Hobbes' philosophy on human nature. The experience highlighted the importance of considering environmental sustainability and long-term thinking in engineering, and the need to address the issue of resource depletion in a more holistic and collaborative manner.

Theme 3: The game was engaging and enjoyable for most, but not all, students.

Students who expressed positive sentiment (24 students) described the game as "impactful", "healthy", "competitive", "resonant", "insightful", and "highly effective". Those students who expressed a negative sentiment (9 students) overlapped with those students whose game ended abruptly due to betrayal or unhealthy competition. They described the game as "conflicting (rules)", "ironic", "unimpactful", "obscured", "predetermined", "confusing", "uninteresting", and "unrealistic". The most frequently stated criticism was that the lack of clarity in the rules led

to confusion within the teams and undefined win conditions. Ensuring that game facilitators are well prepared is essential for a positive experience, as highlighted by this student:

> A tutorial I did not find helpful was the [tragedy of the commons] game tutorial. The technical issues and confusion over the rules did not lead to any fruitful outcome. The game design, however, was interesting and was focused on evaluating or practicing virtues such as fairness, prudence, care, and empathy. I believe the tutorial could be impactful if the game is conducted in a proper fashion.

On the other hand, some students who experienced betrayal by other teams during the activity were still appreciative of the lesson it imparted, as shown in this student's reflection:

> ...my team was eliminated in the second round due to another team violating the "agreed-upon" rules and depleting the remaining fish in the pond. This experience provided a tangible demonstration of the tragedy of the commons, highlighting the vulnerability of shared resources when individuals prioritize their own interests over the collective good.

Theme 4: Games where teams intercommunicated were more enjoyable and led to more favourable outcomes.

The games described as most enjoyable by students were those where teams worked together and communicated to maximize survivability for all teams and minimize consumption from the public pond. These students mostly expressed surprise at the outcome of the game, admiration for their peers, and found the exercise to be interesting and engaging, for example,

> The gameplay and the results did not match my initial predictions, as all villages survived. I thought that one group would have depleted the pond stock to ensure that they achieved self-sufficiency as soon as possible (within the first three rounds), and as a result, some villagers would die. I was especially surprised that one of the groups focused on the welfare of all the groups rather than just investing in their pond. I also noticed a lot of communication between the villages to avoid depleting the stock.

As noted above, games involving betrayal or particularly selfish actions were less surprising for students and led to a stronger negative sentiment of the experience overall.

Rewards were issued after the games were completed to the teams that prioritized the common good, and the success of each group, composed of multiple teams, was shared with the class. One piece of feedback received from students was that the game should go through multiple iterations or take place over a longer period of time to permit greater varieties of outcomes.

Theme 5: Problems with design and rules were a point of frustration for students.

Eleven students expressed frustration or negative sentiment regarding the structure and description of the rules. Students claimed that the game required too much preparation and was confusing, impossible to win, unfair, or excessively complicated. Some students struggled to agree on an appropriate win condition. One student describes the overall general confusion with the game mechanics as detracting from the lessons the game aimed to impart:

> It aimed to teach us about commons, resource management, and sustainability, but it required a lot of preparation and did not resonate as strongly as the other activities. The conversations focused more on the game mechanics than on the underlying concepts, making it less engaging and thought-provoking.

Those students who admitted to betraying their peers in the game claimed that it was only a game and not to be taken seriously, and that they would have acted differently in real engineering scenarios. Some students were very forthright with their unforgiving strategies in the game, for example:

> I learned that the way people make decisions is highly influenced by the potential consequences of the situation. Since we were only playing a game, many groups, including ours, decided to take more fish than needed just because there were no downsides to it. When there were only a few fish left in the main pond, my team took all of the fish we needed to survive, even if it meant other teams wouldn't have enough. It felt as if the other groups would have done the same to us, so it felt like we would be suffering unnecessarily if we didn't.

Similarly, this student suggested that the low stakes of the game led to them acting more selfishly than they would in real life:

> Since the game was extremely low stakes, I felt it hard to relate it to any real situations. I was more inclined to be selfish in the game and do things that I would not do in a real life situation. There may arise some situations during my career where I can make a decision that is beneficial to me, but is not good for other people. The game just didn't relate enough to real life for me to make those connections.

Overall, the lessons learned were mixed. Those teams that had exposure to peers who demonstrated care, fairness, and selflessness had a positive experience with the game, whereas those students who experienced betrayal and callousness seemed unsurprised by the outcome and claimed to learn little through the experience.

Discussion

The data collected in this survey represents reflections and tutorial deliverables from 44 students who experienced the interventions examined in this paper. Feedback was varied, with clear themes emerging from the analysis conducted. All interventions received mostly positive feedback, with students seeing value in each one. The Spectrum Game was described as the most valuable by students with universal support from participants. Virtue Points were also seen as useful, particularly as a mechanism for self-reflection, although accuracy was called into question by many students. The Pisces Game received strongly positive or strongly negative feedback depending on whether the students saw themselves as winners or losers in the game, with the strongest concern being the complexity and facilitation of the rules.

Data for this analysis consisted of graded work collected under secondary use of data. While students were encouraged to speak freely on their assessments, some students may have been inclined toward positive feedback and/ or politically correct responses with the expectation that writing what the instructor wished to hear would lead to higher grades. This concern was also supported by student questions in the tutorial prior to final submission about the expectations around their response and reflection.

The vague wording of the questions for student responses also presented a challenge in generalizing student perceptions. For instance, interpretations of "impactful" varied across students. The intent of the prompt questions themselves could be variously understood, as being for course specific evaluation or improvement, or as opportunities to interrogate students' own affective and critical engagement with the pedagogical methods/ activities. Our analysis was also limited by the lack of opportunity to follow up with the students about their responses.

Although the study collected qualitative feedback from a large number of students, the interventions were attempted within a single cohort during the first delivery of the course. Given that the initial feedback is positive, additional trials of these interventions, including minor alterations from student feedback, will be conducted with larger class sizes.

Conclusion

Three interventions were attempted in a new course on professionalism and ethics for the purpose of realizing scalable, engaging activities that enhance student learning and interest in social topics of engineering. Virtue Points tracking allowed students to learn about how they prioritize engineering and equity virtues relative to their peers. The Spectrum Game encouraged all students to express their point of view on topics of sociocultural importance. The modified Pisces Game allowed students to play through a scenario involving management of a commons, inferring win conditions based on their team biases. Data representing student experiences were collected and analyzed using thematic analysis from tutorial deliverables and course reflective essays.

All three interventions were described as impactful by the majority of students who expressed an opinion on each. The Spectrum Game was most positively received and was successful not only in giving voice to those who were less inclined to share their perspectives, but also led to some students admittedly changing their opinions on sociocultural topics. Virtue Points were described as an effective means of reflecting on individual virtues within a group context, but students had concerns with both accuracy and the correct interpretation of the points assigned. The Pisces Game garnered strongly positive and negative sentiment depending on each student's experience with the game, with many students surprised by games where the common good prevailed and frustrated when a single team acted selfishly to "win" the game at the expense of other teams. Students indicated that they would take the game more seriously if the outcome (win or lose) affected grading.

This study was limited to a single cohort, and all three interventions will continue to be trialed, with modifications to reduce confusion and complexity, in an effort to improve activity value to the students and further improve both impact and engagement.

Acknowledgements

This work was completed on the traditional, ancestral, and unceded land of the xʷməθkʷəy̓əm (Musqueam) nation. All procedures performed in studies involving human participants were in accordance with the ethical standards of the University of British Columbia Research Ethics Board per #H23-03156.

References

[1] D. S. Mower and Philosophy Documentation Center, "Reflections on . . . Shifting the Educational Narrative," *Teaching Ethics*, vol. 19, no. 2, pp. 91–111, 2019, doi: 10.5840/tej20209877.

[2] K. L. Gunckel and S. Tolbert, "The imperative to move toward a dimension of care in engineering education," *Journal of Research in Science Teaching*, vol. 55, no. 7, pp. 938–961, 2018, doi: 10.1002/tea.21458.

[3] E. A. Cech, "Culture of Disengagement in Engineering Education?," *Science, Technology, & Human Values*, vol. 39, no. 1, pp. 42–72, 2014.

[4] M. E. Sunderland, B. Taebi, C. Carson, and W. Kastenberg, "Teaching global perspectives: engineering ethics across international and academic borders," *Journal of Responsible Innovation*, vol. 1, no. 2, pp. 228–239, May 2014, doi: 10.1080/23299460.2014.922337.

[5] EGBC, "Code of Ethics." Accessed: Jun. 04, 2023. [Online]. Available: https://www.egbc.ca/Complaints-Discipline/Code-of-Ethics/Code-of-Ethics

[6] B. Newberry, "The dilemma of ethics in engineering education," *SCI ENG ETHICS*, vol. 10, no. 2, pp. 343–351, Jun. 2004, doi: 10.1007/s11948-004-0030-8.

[7] D. A. Martin, E. Conlon, and B. Bowe, "A Multi-level Review of Engineering Ethics Education: Towards a Socio-technical Orientation of Engineering Education for Ethics," *Sci Eng Ethics*, vol. 27, no. 5, p. 60, Aug. 2021, doi: 10.1007/s11948-021-00333-6.

[8] K. Walczak, C. Finelli, M. Holsapple, J. Sutkus, T. Harding, and D. Carpenter, "Institutional Obstacles To Integrating Ethics Into The Curriculum And Strategies For Overcoming Them," presented at the 2010 Annual Conference & Exposition, Jun. 2010, p. 15.749.1-15.749.14. Accessed: Jan. 28, 2024. [Online]. Available: https://peer.asee.org/institutional-obstacles-to-integrating-ethics-into-the-curriculum-and-strategies-for-overcoming-them

[9] S. S. Clark *et al.*, "An Instructor's Guide to Teaching the Pisces Game for Sustainability Ethics," Aug. 2012, Accessed: May 08, 2023. [Online]. Available: https://keep.lib.asu.edu/items/127597

[10] J. Sadowski, T. P. Seager, E. Selinger, S. G. Spierre, and K. P. Whyte, "An Experiential, Game-Theoretic Pedagogy for Sustainability Ethics," *Science and Engineering Ethics*, vol. 19, no. 3, pp. 1323–39, Sep. 2013, doi: http://dx.doi.org/10.1007/s11948-012-9385-4.

[11] S. Streiner, D. D. Burkey, M. F. Young, R. T. Cimino, and J. Pascal, "Engineering Ethics Through High-Impact Collaborative/Competitive Scenarios (E-ETHICCS)," in *ASEE Annual Conference and Exposition, Conference Proceedings*, Jul. 2021. Accessed: Jan. 28, 2024. [Online]. Available: https://www.researchwithrowan.com/en/publications/engineering-ethics-through-high-impact-collaborativecompetitive-s

[12] S. Clark *et al.*, "An Experiential Pedagogy for Sustainability Ethics," Jun. 2012, p. 25.161.1-25.161.12. doi: 10.18260/1-2--20921.

[13] J. A. Schmidt, "Changing the Paradigm for Engineering Ethics," *Sci Eng Ethics*, vol. 20, no. 4, pp. 985–1010, Dec. 2014, doi: 10.1007/s11948-013-9491-y.

[14] D. M. A. Karwat, W. E. Eagle, M. S. Wooldridge, and T. E. Princen, "Activist Engineering: Changing Engineering Practice By Deploying Praxis," *Sci Eng Ethics*, vol. 21, no. 1, pp. 227–239, Feb. 2015, doi: 10.1007/s11948-014-9525-0.

[15] "Jubilee Media," Jubilee Media. Accessed: Jan. 28, 2024. [Online]. Available: https://www.jubileemedia.com

[16] J. Saldana, *The Coding Manual for Qualitative Researchers*, 4th ed. edition. Thousand Oaks: Sage Publications Ltd, 2021.
[17] G. C. Andrews, *Canadian Professional Engineering and Geoscience: Practice and Ethics*, 4th edition. Toronto, Ont.: Nelson College Indigenous, 2008.
[18] C. E. Harris, "The Good Engineer: Giving Virtue its Due in Engineering Ethics," *Sci Eng Ethics*, vol. 14, no. 2, p. 153, May 2008, doi: 10.1007/s11948-008-9068-3.
[19] S. Vallor, *Technology and the Virtues: A Philosophical Guide to a Future Worth Wanting*. New York, NY: Oxford University Press, 2016.
[20] M. A. Warren and M. T. Warren, "The EThIC Model of Virtue-Based Allyship Development: A New Approach to Equity and Inclusion in Organizations," *J Bus Ethics*, vol. 182, no. 3, pp. 783–803, Jan. 2023, doi: 10.1007/s10551-021-05002-z.
[21] C. K. Lo and K. F. Hew, "The impact of flipped classrooms on student achievement in engineering education: A meta-analysis of 10 years of research," *Journal of Engineering Education*, vol. 108, no. 4, pp. 523–546, 2019, doi: 10.1002/jee.20293.
[22] A. P. Markopoulos, A. Fragkou, P. D. Kasidiaris, and J. P. Davim, "Gamification in engineering education and professional training," *International Journal of Mechanical Engineering Education*, vol. 43, no. 2, pp. 118–131, Apr. 2015, doi: 10.1177/0306419015591324.
[23] G. May, R. N. Bellah, D. Bromwich, and C. C. O'Brien, *The Social Contract and The First and Second Discourses*. Yale University Press, 2002. Accessed: Feb. 02, 2024. [Online]. Available: https://www.jstor.org/stable/j.ctt1npwsh
[24] T. Hobbes, *Leviathan*, First Edition. Harmondsworth, Meddlesex: Penguin Classics, 2017.