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Student-Generated Infographics and Videos for Learning about Professional Obligations and the Impact of Engineering on Society

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Introduction

Both professional and non-professional programs identify the importance of providing students with opportunities to develop professional skills as an outcome of higher education [1]-[3]. This is especially relevant in engineering, where accreditation bodies require engineering programs to be designed to include professional skills development, in addition to focusing on scientific and technical knowledge. For example, student outcomes specified by the Accreditation Board for Engineering and Technology (ABET) and the Canadian Engineering Accreditation Board (CEAB) include the following [4], [5]:

- generating engineering solutions that meet specified needs and with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors,
- communicating effectively to different audiences,
- recognizing ethical and professional responsibilities when faced with engineering situations and resolving any dilemmas while accounting for the impact of solutions in global, economic, environmental, and societal contexts, and
- functioning effectively in a multi-disciplinary team.

A number of approaches to provide students with opportunities to develop the necessary skills and competencies associated with these outcomes have been considered, e.g., targeted workshops and developing and embedding specific activities or learning modules in technical and capstone project courses [6]-[9].

In this paper, we study two alternative assessments—student-generated infographics and videos—as a means for students to learn about the multi-disciplinary nature of engineering, the professional obligations and responsibilities of engineers, and the impact of engineering on society. Student-generated content has been shown to be effective at facilitating learning, promoting active learning, engaging students as they create diverse learning artefacts, promoting critical thinking, and developing digital and communications skills [10]-[15]. Students have also mentioned that they enjoy these alternative ways to demonstrate their learning and appreciate the difference compared to traditional assessments. We describe the implementation of infographic and video assignments in a first-year course on the engineering profession, document student feedback/responses on these assignments, and examine their impact in terms of developing 'professional' skills and competencies.

Implementation Details

Course Logistics

At McGill University, *Introduction to the Engineering Profession* is a compulsory course taken by students from all engineering programs in their first year of studies. The course introduces the engineering profession and notions of engineering practice, as well as discusses professional conduct and ethics, the engineer's duty to society and the environment, engineering for sustainability, and occupational health and safety. The learning outcomes, specified on the course outline, are that students should be able to:

- formulate an opinion on the necessary skills and competencies to be successful as an engineer,
- use principles of engineering professional values, ethics, and equity, diversity, inclusivity, and accessibility (EDIA) to address issues in professional practice,
- explain how the field of engineering is inter-disciplinary,
- assess critical issues in engineering using concepts related to sustainability and global engineering,
- explain basic technical concepts from various engineering disciplines,
- experience teamwork,
- improve their ability to communicate in written and/or oral forms, and
- describe the skills needed for life-long learning.

The majority of these learning outcomes are related directly to a subset of the ABET and CEAB student outcomes described in the introduction.

The course enrolment is typically 360 students per semester, divided in 2 sections with each meeting for 90 minutes per week (there are 13 weeks of classes). The course uses a combination of flipped and active learning instructional strategies: content is provided to the students outside of class in the form of instructional videos and readings while students work in teams during class discussing different engineering-related scenarios, situations, or dilemmas. The students are assessed based on the following: (1) individual or team responses to the engineering-related scenarios, situations, or dilemmas discussed in teams in class; (2) a reflective paper on the engineering profession, (3) a peer-reviewed paper on addressing a professional dilemma in engineering, and (4) two team-based assignments—an infographic and a video. Students are assigned to teams randomly by the instructor at the start of the semester (a maximum of 6 students per team) and work in the same team throughout the semester, i.e., for the in-class discussions and the two team-based assignments.

To facilitate team building, students participate in a number of ice-breaking activities. Teams are coached on creating a team contract, which they can revise around the midpoint of the semester; they are also provided with strategies for managing conflict. In the class one week prior to the due date of the infographic, students are provided with time to work on both the infographic and video assignments; the instructor and teaching assistants (TAs) are available to provide feedback on works-in-progress and discuss (and help resolve) any issues that the teams might be experiencing.

Infographic and Video Assignments

The infographic and video assignments focused on having the students consider the engineer's responsibility to society, how an engineering project might impact society and the environment, and what issues related to ethics and EDIA might arise. Working in teams, students perform research, synthesize results, and then communicate them through the creation of an infographic and a video.

For the infographic, students examined a global incident, event, or issue in terms of engineering professional values and the impact of engineering on society and communicated the information in the form of a *static infographic*. Within a maximum of 2 pages (8.5” × 11”, double sided), the infographic needed to (1) describe and inform about the incident, event, or issue, including relevant quantitative data and a historical timeline (the content should be fully comprehensible by someone with no prior knowledge of the topic) and (2) discuss the impact on society and of the situation within the context of engineering professional values (specifically the responsibilities of an engineer and their obligation to society). Potential topics to consider included the VW emissions scandal, the Boeing 737 Max 8 crisis, or the emergence of generative AI. Students were also encouraged to choose their own topic (which needed to be approved by the instructor). To gather information, students had to use at least 2 to 3 references beyond Wikipedia. Although no specific infographic design tool was required, students were encouraged to use Canva, Piktochart, or simply PowerPoint. Students had 5 weeks to complete the infographic; after 2 weeks, they were required to submit a check-in in which they stated the topic of the infographic and provided a work plan with a list of tasks and responsibilities for each team member.

For the video assignment, students had to create a 5 minute video that describes how engineers from at least two different engineering disciplines must work collaboratively with professionals from non-engineering fields, e.g., medicine and health sciences or social sciences and humanities, etc., to tackle an engineering project or challenge. They also had to examine how the project might impact society and the environment, what issues related to ethics and EDIA might arise, and how these could be resolved. Students did not need to come up with an original project; they could consider any of the grand challenges defined by the National Academy of Engineering [16], Engineering Deans Canada [17], or associated with the 17 UN Sustainable Development Goals [18]. As with the infographic assignment, students had to consult at least 2 to 3 references beyond Wikipedia for research. They were free to choose the video style, e.g., a visible narration, integration of existing videos and pictures, textual representation, digital animation, handmade animation, or interview, etc. [19]. Students had 11 weeks to complete the assignment and after 5 weeks, they were required to submit a check-in (topic and work plan).

Both the infographic and video were assessed according to the criteria shown in Table 1, with each criterion being weighed equally in determining the overall grade. Each infographic and video was evaluated by 2-3 TAs and/or the instructor and an average score was computed based on 3-4 evaluations.

As part of their submissions, each team needed to include a description of their teamwork, e.g., organization of their work plan and the contributions of each team member. In our evaluation, we focused on whether or not students organized, created, and executed their work plan (based on the check-in and final submission) and if changes were made, these needed to be specified and explained. No specific tool such as CATME or Eduflow was used for managing teamwork, though this might be useful in the future for peer evaluations and self-assessment. Moreover, while the infographic and video assignments involve visual formats, our evaluation criteria did not address explicitly the quality of the design/visual format as the emphasis was on content. However, any graphics that were used, e.g., plots, data, images, etc., needed to be relevant to the discussion and assist in communicating the content.

Table 1. Criteria used to assess the infographics and videos.

Criterion	Description
Clarity and accuracy of the information and content provided	**Infographic** • Is the information/content presented accurate, describe the topic clearly, and address the impact of engineering on society as well as discuss the situation within the context of engineering professional values?
	Video • Is the description of the engineering project clear? • Is the need for engineers from two different engineering disciplines to work collaboratively with someone from a non-engineering discipline properly justified within the context of the engineering project? • Does the video discuss possible impacts of the project on society and/or the environment? • Are potential issues related to ethical and professional concerns, as well as EDIA considered? • Does the video address how potential issues (impact on society and/or the environment; ethical and professional concerns; and EDIA) can be reduced or resolved?
Organization and structure	• Is the information/content organized in a logical manner and easy to follow?
Use of visuals and graphics	• Are visuals and graphics used in an appropriate manner? Specifically, are they linked to the discussion/description of the situation (i.e., relevant) and do they help in communicating information?
Adherence to submission guidelines and format	• Have the submission guidelines and format (e.g., number of references, dimensions, length, etc.) been followed?
Teamwork	• Has the work been properly organized, with clear tasks assigned to each team member? • Did each team member participate and/or contribute to the assignment as originally planned? If not, are the reasons for adapting the organization of work justified properly?

Methods

Our study involved analyzing the use of the infographic and video assignments in two semesters: Winter 2023 with 359 students divided in 61 teams and Fall 2023 with 373 students divided in 64 teams. In addition to examining the grades obtained (for all of the students/teams), students were invited to participate voluntarily in the study, which included completing a self-evaluation survey. We examined their responses to the self-evaluation survey as well as to two reflective writing exercises: an exit ticket and a paper on the engineering profession. Note that the self-evaluation survey was not anonymized in order to allow us to associate their responses to the survey questions with their reflective writing exercises. The study was approved by the university's Research Ethics Board.

Self-Evaluation Survey

At the end of the semester, students were invited to complete a self-evaluation survey, similar to a self-assessment of their learning gains [20]. The self-evaluation survey included questions on a 5-point Likert scale with ratings ranging from "strongly disagree" to "strongly agree" asking students about their understanding of the role of engineers, the professional obligations of an engineer, and the impact of engineering on society, as well as the development of professional skills. The survey also included open-ended questions about the students' appreciation of the infographic and video assignments, e.g., what they found more useful, less useful, and whether or not the knowledge gained will be useful for them.

Reflective Writing Exercise 1 : Closing Activity / Exit Ticket

At the end of the last class of the semester, students completed a closing activity based on the triangle-square-circle exit ticket. Specifically, students were asked to write about the following: (1) three important take-aways from the course, (2) a point that resonates or "squares" with their thinking, and (3) a topic that they did not understand or is still "circling" in their mind. Such closing activities / exit tickets are used to obtain feedback on students' understanding at the end of a class (in this case, at the end of the course) and to provide students with an opportunity to reflect on what they have learned [21]. An iterative process was used to analyze/code the responses and determine key ideas:

- the three important take-aways included (1) the multi-disciplinary nature of engineering, (2) that engineers require both technical proficiency as well as professional skills (particularly teamwork and communication), (3) engineering involves more than just technical work, (4) making ethical decisions, (5) the importance of accountability and responsibility, (6) the impact of engineering on society and sustainability, and (7) EDIA,
- a point that squares with their thinking included a (1) a commitment to engineering for sustainability, (2) ensuring EDIA and social responsibility in engineering work, (3) a strong sense of ethics, and (4) being able to communicate, and
- a topic that is still circling included (1) ethics and making a decision that balances technical constraints and ethics, (2) concrete actions to demonstrate social responsibility, and (3) EDIA.

Reflective Writing Exercise 2 : Reflective Paper

We examined student responses to their reflective paper on the engineering profession as a separate measure or indication of learning gains. The paper was not expected to exceed 1 page (or approximately 500 words) and students could choose to write about (1) a description of what they would like for their first post-graduation professional experience and what kind of skills they think would be required or (2) a letter to themselves that begins with the following: "As an engineer, I will be someone who takes on responsibility for making positive contributions to society and human kind through advances in applied science and technology. Based on what I know about the engineering discipline, I think I can (*or will or should*) participate in the following ways in responding to challenges facing human kind…". The paper was assigned in the first class and due at the end of the semester; students had to submit a check-in by the third class describing their initial thoughts and ideas. Towards the end of the semester, they were asked to re-read their original thoughts and ideas and complete their paper, including a discussion of whether their initial thoughts and ideas had evolved and what led to any changes (or lack thereof). The papers were evaluated by the instructor using two criteria: content (the paper demonstrated critical thinking in applying course concepts and relevant connections were made through contextual explanations) and growth (the paper demonstrated personal growth and awareness of deeper meaning and substantial depth in perceptions). An iterative process was used to analyze/code the papers to identify emerging ideas, which focused on the following:

- technical skills and knowledge,
- professional skills, particularly teamwork, communication, and leadership,
- personal attributes,
- continuous development and life-long learning,
- professional values, obligation and duties as an engineer, and commitment to society,
- ethics, ethical decision making, and EDIA,
- understanding the impact of engineering on the environment and society, and sustainability.

Results and Discussion

A total of 39 students from both semesters participated in the study. The number of participants is low and may be due to the non-anonymous nature of the self-evaluation survey. It may also reflect the students' general engagement for completing surveys, e.g., the response rate on the course evaluations was only 13.3% in Winter 2023 and 22.8% in Fall 2023. Table 2 summarizes the demographic information of the student participants.

Table 2. Demographic information of the student participants in the study.

Category	**N**	**%**
Total	39	100
Gender		
Female	18	46.2
Male	20	51.3
Non-binary	1	2.5
Where did you last study before coming to McGill?		
Québec	23	59.0
Canada (excluding Québec)	8	20.5
US	3	7.7
International (other than US)	5	12.8

Evaluation of the Infographics and Videos

The average grades for the infographic and video were 19.5/20 and 19.2/20, respectively in Winter 2023; for Fall 2023, the corresponding average grades were 17.9/20 and 17.6/20. The grades were lower in Fall 2023 and may be due to a revision of the evaluation criteria. Specifically, while the general scoring rubric remained the same, the description of the criterion on content was made more elaborate in terms of discussing the impact of engineering on society and identifying and addressing issues related to ethical and professional concerns, as well as EDIA and recommending possible solutions. Nonetheless, it was clear from the submitted work that the majority of the students had considered a broad range of issues with regards to the impact of engineering on society and in terms of concerns related to ethics, the engineering profession, and EDIA.

For the infographic, in addition to the proposed topics, students also investigated, amongst others, events related to infrastructure (e.g., the collapses of the Québec Bridge, Genoa Bridge, and Hyatt Hotel Walkway, the explosion of the San Bruno pipeline, and the Lac Mégantic rail disaster); nuclear power (e.g., Chernobyl and Fukushima); the automotive industry (e.g., self-driving vehicles, Ford Pinto controversy, development of the 3-point seat belt); biomedical products (e.g., computer-controlled radiation therapy and implantable brain-computer interfaces); the Challenger Space Shuttle disaster; and Batterygate.

We now highlight some of the student responses in terms of discussing the impact of the event on society and of the situation within the context of engineering professional values. For example, the students that considered the development of the 3-point seatbelt described how Volvo followed a good works model:

"Nihls Bohlin invents the 3-point seatbelt for Volvo, which ends up being much safer than earlier seatbelts. Volvo chooses to allow other companies to use the design for free. Showcasing commitment to responsibility and their societal obligations. Engineers must be responsible and commit to the betterment of society. They must hold paramount the safety and welfare of the public. By not patenting their seatbelt, all cars could be made safer. Volvo & Bohlin fulfilled their responsibility to society by ensuring that more people could access 3-point seatbelts, making roads worldwide a safer place."

As a second example, students that examined the Ford Pinto controversy commented on how engineers (and companies) must place the safety of the public and society above personal gain or the interests of the company:

"This Pinto case reveals the moral dilemmas faced by the engineers involved. Ethical engineers may have felt a deep sense of responsibility to protect human lives, making the decision to release a flawed design a conflicting choice for them. Ultimately, the decision to release the Pinto was ultimately made at a higher corporate level. This case stresses the importance of creating an ethical corporate culture that encourages employees to act in alignment with their personal and ethical values, and ensures that their concerns about safety and well-being are heard, even in the face of competing interests."

For the video, students considered a broad range of engineering projects or challenges, including those related to biosystems and health (e.g., telehealth, automated insulin delivery, gene editing tools, etc.); access to clean water, renewable and alternative energy sources (e.g., nuclear, solar, hydroelectric); sustainable and inclusive industrialization, infrastructure (e.g., smart homes or cities, earthquake resilient infrastructure, green skyscrapers); construction over indigenous territories where there is the possibility of human remains; and transportation. The most common video style was a visible narration (slides and graphics with a voice-over); however, many teams showed creativity in using handmade animations and live interviews/documentaries. Note that students were informed that a professional-level video was neither required nor expected and that the evaluation would focus on the content and use of the visual aids/graphics to help explain their points. For teams that produced interview/documentary style videos, they appeared to have been recorded using smartphones. Generally, the videos described clearly the project/challenge and the collaborative roles of the engineers with non-engineers. Most also described in detail the impact of the project on society and considered in depth how ethical, professional, and EDIA issues could arise and be addressed.

For example, one team of students provided a comprehensive description of the challenge of providing clean water to remote communities in northern Canada. They highlighted numerous issues that needed to be addressed, ranging from environment and ecological to logistical and fiscal. They discussed in detail how geotechnical engineers, responsible for analyzing soil and rock and the impact on water sources, needed to work with mechanical engineers developing the water treatment systems and equipment and toxicologists who assess types and levels of contaminants and define the standards for safe drinking water. They examined how construction activities can affect the ecosystem, how the infrastructure can impact the landscape, and how operations might increase energy consumption and generate waste. They described solutions based on engineering for sustainability practices, utilizing renewable energy sources, and collaborations with environmental agencies. They explained the positive impact of the project on society, including reduction in waterborne diseases, enabling agricultural activities, strengthening community resilience, fostering greater social cohesion, and addressing EDIA issues related to the lack of accessibility to clean water.

Student Appreciation of the Activities

Figure 1 summarizes the students' appreciation of the infographic and video assignments based on their responses to questions from the self-evaluation survey. Most expressed a high level of interest and found them to be relevant to the course. They also found the grading rubrics to be clear and the level of difficulty to be appropriate. Student comments on the less useful aspects of the assignments included spending too much time or effort on creating graphics or an aesthetically pleasing video (including video editing) as well as the constraints on space or time (i.e., 2 pages for the infographic or 5 minutes for the video). On the other hand, students found the assignments useful in terms of applying knowledge from class (e.g., standards of responsibility), learning about engineering values, analyzing the impact of engineering mistakes on society, doing research, getting exposed to new issues in engineering, appreciating the multi-disciplinary nature of engineering (including working with non-engineers), and the freedom to choose their topics.

In response to an open-ended question on whether the knowledge gained would be useful, students indicated that they learned to communicate better, work better in teams, and think more about the impact of their work as an engineer. Sample student comments include the following:

"I am now more aware of engineering projects' impact on all aspects of society. It will make me more cautious when choosing a project by sticking to my values and professional ethics. I am now aware that even big companies can create a harmful scheme. The video assignment showed me the beauty of collaboration with all professionals. Everyone included in my future career will have an important voice for us to improve the project."

"The infographic assignment showed how easy it is to "stray off the path" and abandon enginerial [sic] responsibilities. Theoretically, we all know that we shouldn't do bad things and so it seems silly to learn about ethics, but having to analyze such a scenario makes you realize how real these things are and how you need to be really aware of the effects your profession has on the world."

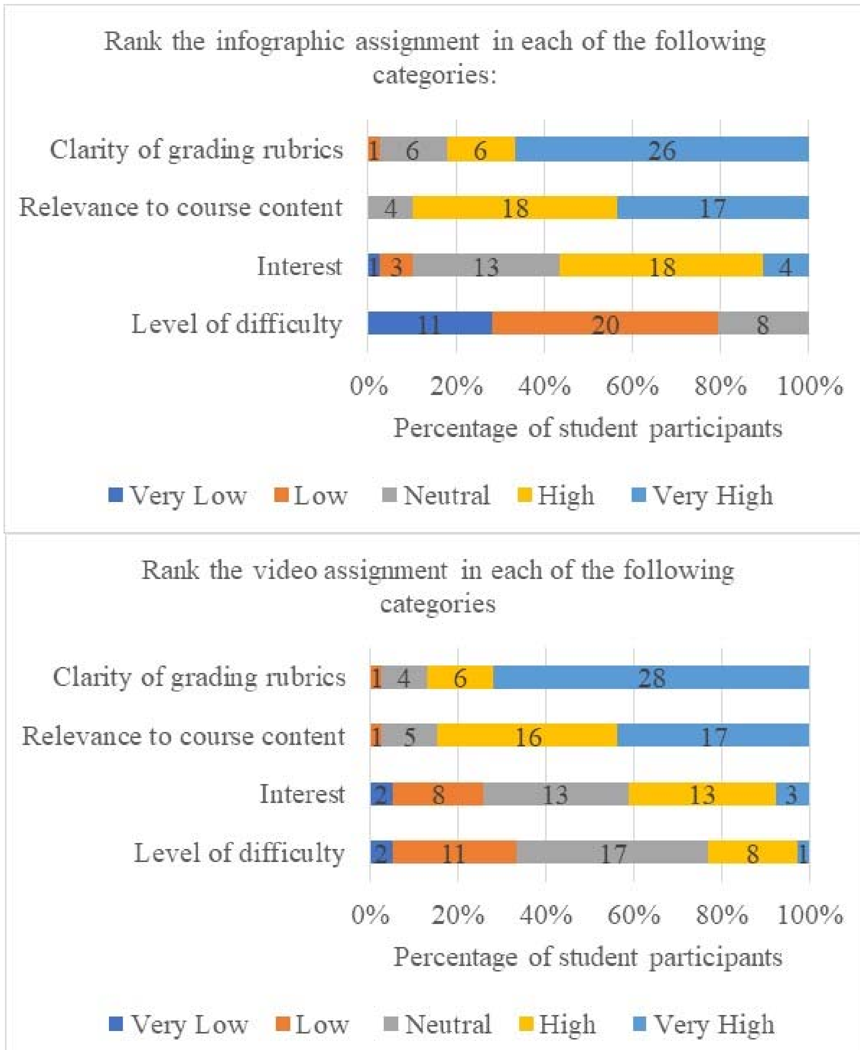

Figure 1. Student appreciation of the infographic and video assignments (N = 39).

Finally, 75% of the students indicated that they would like to see the use of infographics and video assignments in other courses as they allow for greater creativity and found the end result to be more rewarding than producing a paper. For example, students mentioned:

"I liked the way it incited us to do some research and put it all on an using an infographic about a recent global engineering issue, which I sadly wasn't aware of before. It was a creative way to go about an assignment instead of having to write a paper."

"I would like to see more assignments like these because I find them more interesting and engaging compared to writing a paper or taking an exam."

"The open-endedness of this assignment was great - students were able to express the information in creative manners that mattered to them."

"I learnt how to use my creativity and synthesize my research. For instance, I retrieved information that was the most pertinent and tried to explain it through an infographic and a video in order for others to understand and take an interest in the subject chosen. It allowed me to use my creativity in order to render the assignments visually stimulating as well."

Self-Evaluation of Learning Gains

Figure 2 summarizes the students' self-evaluation of their learning gains. All students agreed or strongly agreed that they have a better understanding of the engineering profession, and in particular, with regards to their responsibilities and obligations as an engineer and the impact of their work as engineers on society. They also expressed being comfortable with explaining the social obligations and responsibilities of an engineer to the general public. Finally, most students expressed an increased interest in their professional responsibilities and social obligations as an engineer.

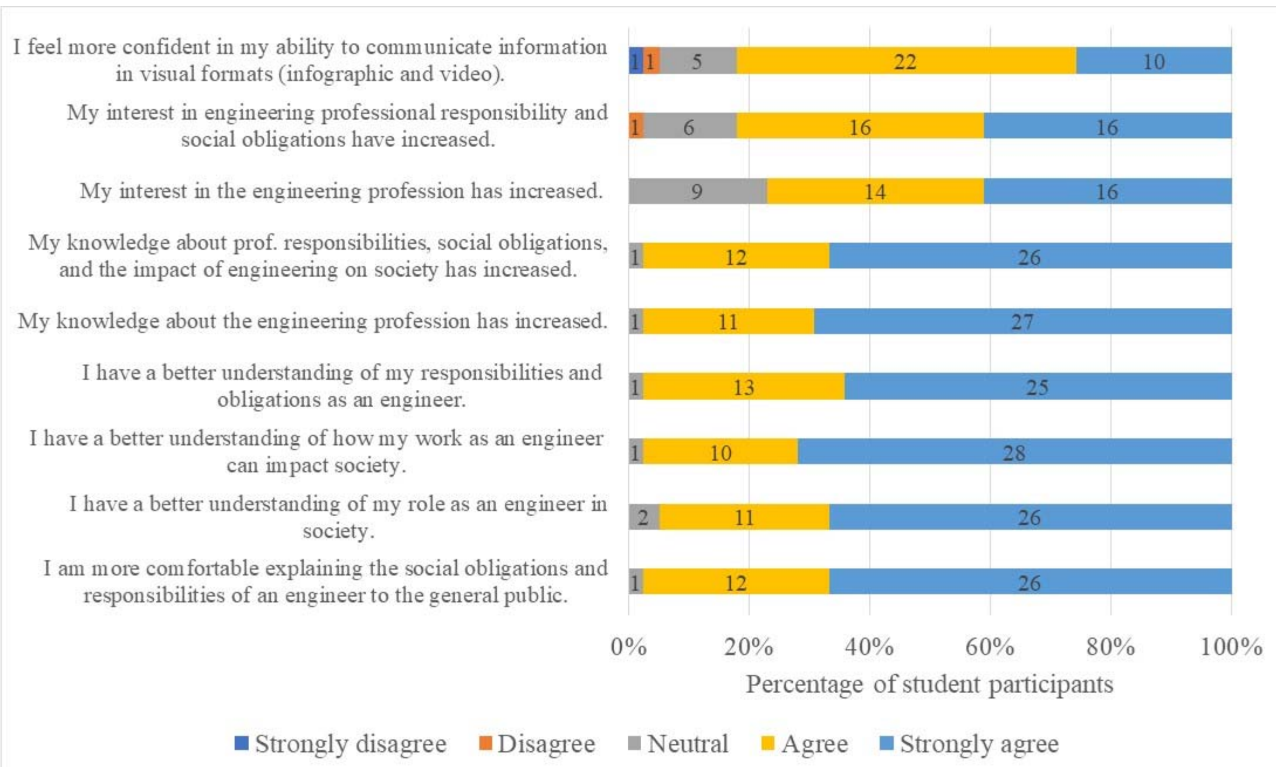

Figure 2. Student self-evaluation of learning gains (N = 39).

Responses to Reflective Writing Exercises

The coded responses to the exit survey and reflective paper showed that many of the ideas were common to both (and mentioned by some students in both). We grouped the ideas into two main categories, one focused on skills and the other on the role of the engineer. While technical skills and knowledge as well as professional skills (particularly teamwork and communication) were the focus of the skills category, ideas related to personal attributes (such as perseverance and curiosity) and continual improvement and life-long learning are included. The role of the engineer category includes ideas associated with the multi-disciplinary nature of engineering (e.g., working with other engineers and non-engineers), that engineering does not only involve technical work, making decisions that must balance technical vs. ethical and/or professional considerations, professional values, impact of engineering on society and sustainability, ethics, and EDIA.

Table 3 shows the two categories and associated ideas, and the number of times each was mentioned in the exit survey and reflective paper.

Table 3. Categories of ideas coded from the exit survey and reflective paper on the engineering profession, along with the number of mentions for each idea. Total number of student participants (N = 39).

Categories and ideas	**Number of mentions**		**Total number of mentions**
	Exit survey	**Reflective paper**	
Skills			
Technical skills and knowledge	14	23	65
Professional skills (teamwork and communication)		28	
Personal attributes		4	4
Continual development and life-long learning		5	5
Role of the engineer			
Multi-disciplinary nature of engineering	10	2	12
More than just technical work	4		4
Making decisions that balance technical vs. ethical/professional considerations	3		3
Professional values, obligations and duties as an engineer, responsibility and accountability towards the public	15	9	24
Impact of engineering on society and the environment, social responsibility, commitment to society, sustainability	32	23	55
Ethics and ethical decision making; EDIA	41	22	63

As evident from Table 3, students discussed frequently various skills in the reflective writing exercises (a total of 74 times). This might be expected given that for the reflective paper, 29 of the students wrote about their first post-graduation professional experience and the kinds of skills and knowledge they would need to be successful. However, ideas related to the role of the engineer were mentioned more than twice as frequently (161 times). Of specific note are the references to the need to have a strong sense and understanding of ethics and EDIA to guide decision making when faced with dilemmas (63 times), the impact of engineering on society and sustainability (55 times), and a commitment to professional values and the obligations, duties, and responsibility of the engineer (24 times). These ideas emerged in the exit survey and reflective paper, and even in the papers of students writing about their first post-graduation professional experience. It is also interesting to note that the ideas of engineering involving more than technical work and having to make decisions that balance technical constraints vs. ethical/professional considerations received 7 mentions. The number of references to the role of the engineer in the reflective writing exercises tends to correlate with the results of the students' self-evaluation of learning gains.

While some of the responses to the exit survey and reflective paper were brief and written in a more 'mechanical' manner, e.g., using bullet points, most students were very elaborate and supported their reflections with concrete personal examples. In these cases, the tone of the writing was overwhelmingly positive. Taken together, this suggests that exposing the students and providing them with opportunities to learn about and reflect on the professional obligations of an engineer and the impact of engineering on society can impact their perceptions of the engineering profession.

Conclusions

Based on teaching assistant / instructor evaluations of the infographics and videos, students demonstrated the ability to assess an engineering event or situation within the context of the responsibilities and obligations of the engineer towards society as well as the impact of engineering on society. They were also able to give examples of how issues related to ethics and EDIA might arise and how they can be resolved. The self-evaluations of learning gains indicate that students have a better understanding of their responsibilities and obligations to society and of how their work as an engineer can have an impact. Student responses to the reflective writing exercises agree with these self-reported learning gains.

One drawback of this study is the limited number of student participants. Rather than inviting students to participate in the study at the end of the course, another possibility is to incorporate self-evaluation of learning gains directly as part of the assignment, i.e., while the creation of the infographic and video remains team-based, each student can also be asked to complete and submit a self-evaluation of their learning gains and appreciation of the activity. Overall, the student responses are positive and encouraging, and coupling these two forms of alternative assessments in the course with other activities, such as reflective writing exercises and in-class discussions, can provide a useful means to engage students with learning about the obligations and responsibilities of an engineer as well as the impact of engineering on society.

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