IMPACTS AND ETHICS OF BIOTECHNOLOGY AS A VEHICLE FOR ASSESSING CEAB OUTCOMES IN A FIRST YEAR CHEMICAL ENGINEERING COURSE AT THE UNIVERSITY OF WATERLOO

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Abstract - *The CEAB outcomes "Impact of Engineering on Society and the Environment", and "Ethics and Equity" differ from the majority of the technical content of engineering curricula. These outcomes largely involve the affective learning domain rather than the cognitive domain. Teaching and measuring affective domain outcomes can be challenging and has received limited attention in engineering curriculum.*

To help address this disconnect, we have selected to integrate ethical considerations within an engineering course, namely the first year Engineering Biology course of the Chemical Engineering program at University of Waterloo.

This learning activity was successful in providing an opportunity for students to establish a sense of awareness as to the impact of engineering on society and the environment. It also created opportunities for students to practice and develop their communication skills. Next steps should consider the potential need to formally expose students to the ethical decision making process and to evaluate if this type of teaching has modified the student awareness of ethics, social values and responsibilities of the engineer.

In this paper, we will comment on the successes and challenges faced in promoting student learning and fairness in a structured panel format learning activity. The careful design of assessment tools will also be discussed.

Keywords: CEAB outcomes, engineering ethics, impacts of technology, panel discussion, student active learning

1. INTRODUCTION

The CEAB outcomes "Impact of Engineering on Society and the Environment" and "Ethics and Equity" differ from the majority of the technical content of engineering curricula [1,2]. These outcomes largely involve the affective learning domain rather than the cognitive domain. Teaching and measuring affective-domain outcomes can be challenging and their integration with engineering knowledge is generally limited. A recent paper reports on the low manifestation and measurement of the CEAB graduate attributes, Ethics and Equity in the Faculty of Engineering at the University of Manitoba [3]. The findings of the study, based on the response of fifteen instructors using a self-administered checklist, indicates little evidence that Ethics and Equity were included and measured in their courses during the 2012-2013 academic year. This being said, professional responsibility and ethical behaviour will be generally present in courses exclusively devoted to these topics [4]. Stand-alone courses in ethics are beneficial in providing a good basis of the major ethical theories and their application to real and hypothetical cases. But this approach fails in exposing students to engineering applications of ethics. It is disconnected from the engineering practice where engineers will be asked to connect scientific and technological advancements to the needs and the development of society, formulate opinions and judgments and make ethical decisions. In this context, there are opportunities in technical courses to connect theory to real life situations and reduce the gap between curriculum and engineering practice.

2. LEARNING ACTIVITY

To help address this disconnect, we have developed an ethics based learning activity in the first year compulsory Engineering Biology course of the Chemical Engineering program at University of Waterloo. Our intention was to use examples of biotechnological applications to allow students to make connections between biotechnology and ethics and morale values and make students aware of the social dimensions of biotechnology. It was not our intention to teach ethics or moral values or to recognize and resolve ethical dilemma. With this in mind, students

were evaluated on knowledge and skills, not on values and beliefs.

The learning activity was based on specific biotechnology applications to create a panel and audience, wherein an ethics topic related to the biotechnology was debated. An expert panel format was shown to encourage student learning in the context of applications of human factors [5]. Examples of biotechnology applications that were discussed include stem cell-derived products, genetically modified organisms (GMO) and biological warfare. Each example was provided with questions to address and an initial scientific publication. Technological, scientific and biological considerations together with ethical, social, legal and financial implications and the role of engineers were addressed. Depending on the class size, which typically ranged from 60 to 80 students, seven to ten topics were discussed throughout the term, one topic for each weekly tutorial session. The class was organized as illustrated in Figure 1.

Students were required to register for a topic in groups of two on a 'first come, first served' basis. Each group of two would have an opportunity to participate on the panel for one session wherein they would initiate discussion and field questions from the audience. In a typical session, five pairs of students would participate as panelists, ensuring that there was sufficient panel-audience interactivity.

The instructor facilitated the discussion by providing a five-minute overview of the biotechnology of interest. Each group of the panel was then given three minutes to present their findings and share their standpoints on the topic with the class. Lastly, the floor was opened to the comments and questions of the audience members.

There was no intervention from the instructor during the discussion. The discussion was modulated by the students and their questions/responses. Interaction between the panel members and the audience was monitored by a volunteer student.
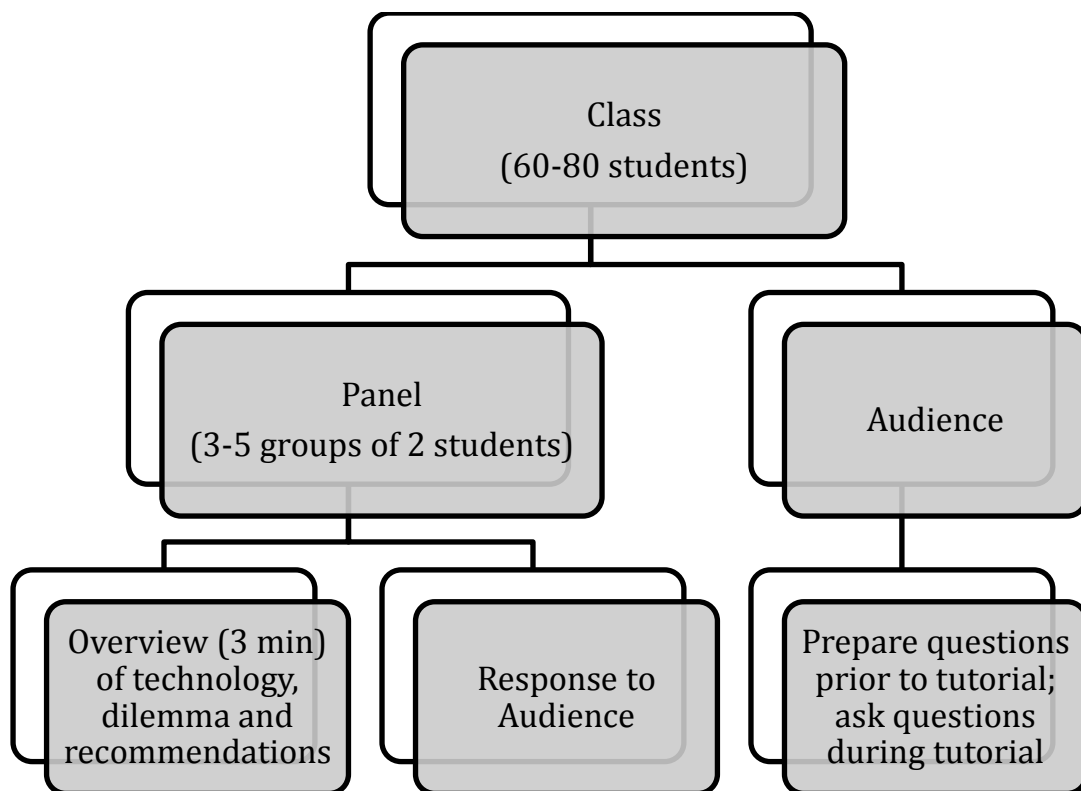
Figure 1: Organization of the panel discussion

This exercise provided an opportunity for students to establish a sense of awareness as to the impact of engineering on society and the environment. It also created opportunities for students to practice and develop their communication skills. Students used their own values and perception of ethics when handling the topic and during the panel discussion.

3. ASSESSMENT

The panel was assessed for their participation and knowledge of the technology, ethics and social considerations of the specific biotechnology. An added bonus to this learning activity was the assessment of communication skills, another CEAB outcome. Oral communications were assessed during the panel discussion while written communications were assessed with the two-page response paper that each pair of panellists was required to submit prior to the panel discussion.

In this presentation, we will comment on the successes and challenges faced in promoting student learning and fairness in a semi-structured panel format learning activity. We will also highlight student feedback, which was supportive of this learning activity. The importance to stimulate student participation while remaining fair to all students and the role of the instructor as a facilitator will be reported. The design of assessment tools will also be discussed.

4. CONCLUSIONS

This panel format learning activity was successful in exposing students to ethics and impacts of biotechnology on society. The panel discussion during the tutorials of the core Engineering Biology course provided a connection with the knowledge covered during the lectures. The engagement of most of the students in this panel format learning activity was beyond our expectations. Most students made significant contributions to the panel discussion showing excellent argumentation skills and reflection, interest and in-depth knowledge of the biotechnology by building on their personal values and external resources. The written communication component was not as successful and did not meet our expectations. This component would need to be revisited and may require more guidance. Key elements for the success of this learning activity were the topic selection and the quality of the initial reference provided to the students.

Good topics were those that students could easily relate to and would have a meaningful societal component.

Integration of the topic to the course content was also important, as well as the size of the panel and the self-monitoring of the class discussion. A number of considerations remain to be examined: should there be formal exposure to ethics and societal values? Are the assessment tools measuring what we want? Should we consider behavioural assessment tools? Has this type of teaching intervention modified the student awareness of ethics, social values and responsibilities of the engineer?

Acknowledgements

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