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Teaching Technology and Society to Engineering Students

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Abstract:- The teaching of technology and society to undergraduate engineering students is open to a variety of approaches. This research note describes the objectives and structure of an interactive, team-work learning course at the University of Manitoba's Faculty of Engineering. To gather student responses to the course and information useful for improving the course, questionnaires were distributed to 80 students and the feedback evaluated. Students reported positively on the variety of learning environments used in the course and the knowledge acquired to broaden their understanding of technology as a shaper of society. They found group discussions valuable in exposing them to different perspectives. Most students also showed a positive response to the group projects as well as to short three-page essays in which they had to “take sides” on an issue. Having to make their own cases motivated them to read more critically and carefully.

Keywords:- Ethic; technology; engineering students; society; in-class group discussion; learn based project

I. INTRODUCTION

The power of engineering and technology as a value-laden, society-transforming and future-shaping agent of change has never been more far reaching than in the times in which we live. Its effects, both positive and negative, are only fully comprehended in hindsight. By the time of comprehension their influences on society or the environment may be so ubiquitous and well established as to be seen as normative, especially to those born into and raised in that society. A greater awareness of the meaning, history, and role of technology in society is needed for all parts of civil society and even more for the engineer. What kind of future do we want and how can technology be best directed towards creating a better world?

In many countries, engineering students are required by licensing bodies to have exposure during their formative studies to the impact of technology on society. This creates awareness of the social, political, personal, economic, ethical and environmental impacts of their work. Despite such exposure, engineers, whose profession places them at the forefront of technological change, are sometimes accused of being so immersed in the development and application of technology that they do not pause to consider its impact on society. They are often criticized as being “mere technologists,” unconcerned with the broader implications of their work as compared with the biologist’s concern with environmental degradation as in [1]. As a result of this passivity, engineers tend to be relegated to the position of technical servants of corporations, governments, and society in general. When a student expressed this view in a class, the instructor, retorted almost involuntarily, “Yes, we train mercenaries.”. It is indeed ironic that engineering, which is an essential social activity, marginalizes itself in this way as in [2].

Whether or not such passivity is a characteristic of engineers, it does have a historical validity in the way engineering has traditionally been taught. Engineering schools primarily saw their role as teachers of the formal technical disciplines, such as manufacturing processes, structures, telecommunication and power systems. The broader implications of technological innovation were not addressed directly in the engineering classroom as in [3]. Even in courses involving integrated knowledge, such as first year engineering design, the social issues were narrowly dealt with as in [4]. Although, the student is encouraged to do teamwork and to behave ethically as in [5], [6], it has been only to optimize the design activity and not to explore its broader implications. Yet, while new issues are continuously arising in emerging technologies, the student is largely buffered from the social implications because design is essentially deemed apolitical as in [7]. The issues are made technical and partly social as in [8], and the focus is mainly on calculations and design as in [9], [10]. Without such exposure to the impact of their work, engineering graduates are ill prepared to make the connection between technology and society.

Keeping the interest and motivation of students early in their education has a positive effect on their subsequent educational experience as in [11]. In most engineering schools today, students are required to take courses in ethics and technology. Yet the instructors of these disciplines are usually not engineers and hence are not seen by the engineering students as professional mentors or role models. The result is a fragmented engineering education, with students leaving school under the impression that their engineering instructors are only concerned with the narrow technological issues, the broader aspects being left to others. It is hardly possible that, under these conditions, engineering graduates will carry with them a vision of technology that will be properly integrated into the affairs of society. Thus, the question of how to most effectively engage the engineering students with the social, political, economic, personal, ethical and environmental impact of engineering and technology continues to be an interesting challenge.

II. THE PRESENT STUDY: A COURSE DEVELOPED TO MAKE A DIFFERENCE

Broadly speaking, the approaches to teaching courses on technology and society for engineering students fall into three categories: historical and anthropological (i.e., history of technology through concrete examples, the roles played by technological artefacts in various cultures); philosophical (i.e., exploration of the different viewpoints, worldviews and outlooks on the nature of technology); and issues-based (i.e., debating technological issues from political, economic, social and ethical perspectives). The course that is of interest in this research note is primarily structured around the issues-based approach as this appeals mostly to the learning style of the majority of engineering students but the other two approaches are also present. The findings from this study on the course demonstrate one way to engage engineering students.

III. METHODOLOGY

A. Course Description

The course title is Technology, Society, and the Future and consisted of three-50 minute class per week over 13 weeks with the goal of focusing on engineering issues.

B. Learning Objective

The primary learning objectives for engineering students included:

- To take ownership of the personal and social dimensions of their role as future engineers.
- To appreciate that technology and society influence one another (i.e., the relationship is not one-way – technology impacting society). Society also has the ability and right to make choices.
- To view technology as a three-legged social phenomenon, involving technique (i.e., tools and technical methods), but also cultural and organizational attributes that can vary from country to country and can change over time, i.e. technology is a sociotechnical system or practice.
- To understand how clashes about the development of technology arise from different world views.
- To examine ideas about the rise of science and technology.
- To reflect on how technology affects our values, norms, social interactions, and politics, and to see how they may even affect brain development.
- To study the role of so-called "invisible technologies" in shaping society.
- To study the nature of technological complexity and its development and management of high risk technologies. To examine the role of risk perception in the public's reactions to different technologies and the factors that influence risk perception.
- To investigate whistle blowing and some common philosophical bases for ethical decision-making.
- To learn how engineers should communicate and interact with the non-engineering public in the planning and execution of engineering projects.
- To consider some of the scholarship on why societies collapse and the question, "Are their limits to growth?"
- To consider the "Limits to Growth" (Meadows, et al) systems model and examine the question of whether or not technology alone can move society towards sustainability?

A specific textbook [12] was selected for its format and content in which various current issues in science, technology and society are debated from the pro and con side. Examples of issues include "Is It Time To Revive Nuclear Power?" and, "Does The Internet Strengthen Social Connections?" It provided a broad selection of current issues which allowed for the facilitation of in-class discussions and hence, was deemed more suited to the problem-solving focus of engineering than other texts that adopted a sociological or anthropological approach (e.g., the social construction of facts and artefacts, or the anthropology of technical skills).

C. Course Material

The textbook was used in two ways. First, specific chapters were assigned for reading and classroom discussion; the students identified the discussions as "good" in an end-of-course survey. Second, five other chapters were selected for a short three-page essay every two weeks in which each student as shown in Table 4 took one side and gave reasons for doing so. The underlying motive for this was to help explore the students' philosophical or world views as they are brought to bear on the topic, and to observe the thoroughness and nature of the students' arguments.

The instructor prepared handouts on the each of the issues. While the textbook addressed specific technologies, the handouts strove to deal with broader issues of technology and society (e.g., limits to growth, the rise of technology, risk, whistle blowing). On a weekly basis, the instructor drew attention to science and technology issues that were making news in the national or international media that week. Occasionally, a short handout on a current issue was provided to students and students were asked to comment.

D. Class Format

The classroom was set up to be interactive, with students divided into pre-arranged teams of four or five students during the first class. These teams were fixed for the course for the purposes of in-class group discussions and for a team project. Each team was identified by a nameplate of a famous engineer or scientist (i.e., Team Westinghouse, Team McCoy, Team Brunel, Team Tesla, Team Von Karman, Team Edison, Team Prandtl, Team Eiffel, Team Stephenson, Team Telford, Team Diesel, Team Ford, Team Da Vinci, Team Watt, and Team Sikorsky) placed on the table where the team would assemble for each class. During class discussions, the team rather than individual students, were asked to respond to questions, minimizing the fear of certain students to speaking in front of a large class. The room was equipped with a wireless microphone so that the teaching assistant could capture individual team responses so that all students could hear them.

The following classroom framework was adopted each week but not with complete rigidity since sometimes a topic required additional lecture time or a guest speaker had to be accommodated: Monday - lecture with brief group discussion; Wednesday - group and whole-class discussion on the text book reading for that week; and Friday - announcements on current science and technology issues "in the news," followed by lecture.

E. Team Project

In addition to five individual reports as noted above, the class was divided into teams and each team assigned one of five topics, with the same topic being assigned to groups of three teams. The team with the best presentation in each group received a certificate of recognition. Groups were allowed to barter with another group for a different topic but needed to inform the Instructor and Teaching Assistant.

The following five topics were specified. In each case, the students were required to make their own case for or against the statement. In cases where a team was divided in its views, permission was given, after consultation with the instructor, to insert opposing views.

Topic 1: The methods of communication, entertainment, and information gathering that have become ubiquitous over the last 10-15 years are leading to a self-absorbed society and one that increases superficiality and shallowness in education, relationships, and politics.

Topic 2: Overall, the impact of the automobile on society has been neutral.

Topic 3: High technology war tools are a danger to peace as they increase the likelihood of the use of force and a decreased sensitivity to war.

Topic 4: Fast food operations are a blight on our society which would be better off without them.

Topic 5: "Our most powerful 21st-century technologies-robotics, genetic engineering and nanotech-are threatening to make humans an endangered species." (Bill Joy, co-founder and Chief Scientist, Sun Microsystems (2000).

Each team was required to complete a 20 page paper (not including figures, tables and appendix) on the assigned topic and to give a presentation before a panel of judges. The report and presentation also had to include the results of a survey in graphical format. The survey involved interviewing 100 people. Students were asked to try to obtain a representative range of ages plus gender balance. It was understood that a survey of this size would not give highly reliable results and that most of the respondents would be answering from a position of limited or no knowledge about the topic (i.e. largely subjective responses). Students were encouraged to conduct the survey early in the course as the responses might give them some useful directions for carrying out research for the paper and also to have them begin engaging with the topic early in the course. A typical survey questionnaire, feedback and some comments are shown in Tables 1 to 3. Figure 1 shows results of the survey.

Table 1: Survey questionnaires on topic 2. 100 copies were handout to public

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Course Evaluation	**Lowest = 1 Highest = 5**				
1. The out-of-class survey conducted by groups was a valuable exercise.	1	2	3	4	5
2. The variety of learning environments (lectures, guest speakers, group discussions, essay, and group project) increased my learning.	1	2	3	4	5
3. In-class group discussions were valuable because they exposed me to different perspectives.	1	2	3	4	5
4. The group project gave me opportunity to consider issues in depth.	1	2	3	4	5

Table 2: Compiled data of survey on the impact of the automobile on society

Topic 2: Overall, the impact of the automobile on society has been negative, neutral or positive? **Choose our respond and make your case.**		
1. Gender: Male Female		
2. Age: 20 - 25 26 - 30 31 - 40 41 - 50 above 50		
3. Education / Work experience		
3.1 Engineering / Technology		
3.2 Science		
3.3 Business / Administrative		
3.4 Liberal Arts		
3.5 Others		
Positive = 1, Negative = 0		
1. In your opinion, has the car, on balance, had a positive or negative impact on society?	1	0
2. If you answered "positive," what has been the most positive impact in your opinion?	1	0
3. If you answered "negative," what has been the most negative impact in your opinion?	1	0

Table 3: Popular comments

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Positive	Mobility	Create job	Connection	Freedom
Negative	Population	Death toll	Using up oil	Accidents

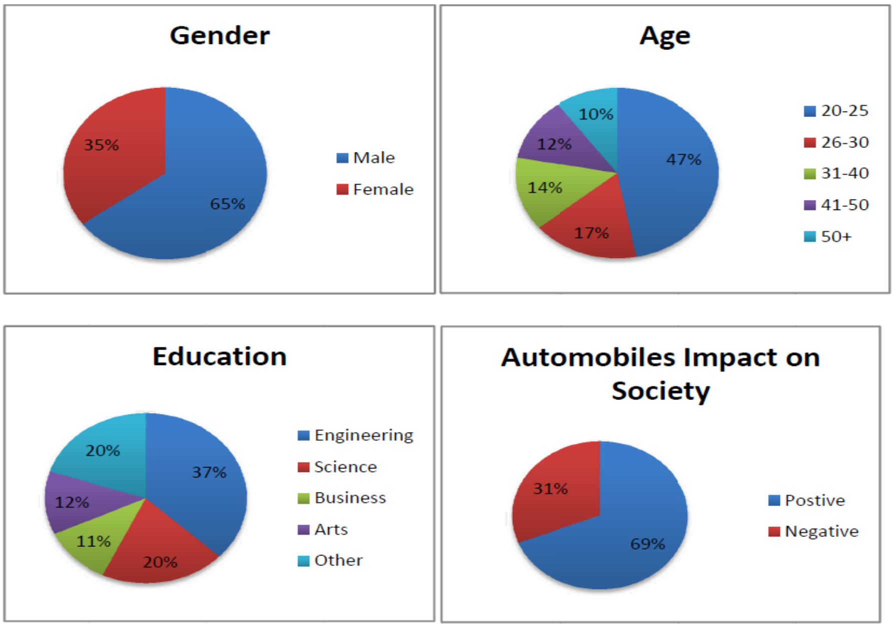

Figure 1: Shows results of the survey.

Before proceeding with the full report, each team was required to write an outline of the proposed content for review, comments and further suggestions by the course instructor. Sometimes students began as enthusiastic proponents of a particular issue, only to become sceptical or opposed to it as their study progressed. The instructor and teaching assistant encouraged this personal development in class. Through this experience, students were able to appreciate the importance of rational analysis as opposed to preconceived notions.

One of the difficulties in team-based projects was evaluating the contributions of each student as the marks for the team report and the team presentation are representative of the aggregate effort of the students. The approach used in this course to assess, albeit not in an absolute, objective way, the degree to which students had contributed less or more than others in their teams was as follows. Each student completed a form in which he/she was to imagine him/herself as the manager of a "consulting" team and to recommend to upper management a division of a bonus of $100,000 among the team members (excluding themselves) based on their evaluation of performance in a number of different areas. A correction factor was calculated from the data and the overall marks adjusted up or down. The $ values assigned were, of course, treated confidentially by the instructor.

F. Final Exam and Weightings of Course Components

A final examination comprising three sections was given in order to examine the student's comprehension of the subject matter not covered in the five bi-weekly reports but based other readings from the text and handouts. As well as providing evaluation of this material, the examination also clearly discriminated between students who had studied and understood the subject well and those who had not. The two hour final examination was sectioned into three components – multiple choice, definition of terms, and two short essays. The weightings for each component of the course are shown in Table 4.

Table 4: Course component weightings

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#	**Course Components**	**Weightings (%)**
1	Group Project (Outline Report)	5
2	Group Project (Full Report)	25
3	Group Project (Presentation)	15
4	Bi-Weekly Reports from "Taking Sides"	20
5	Final Exam (2 hours)	35
6	Total	100

G. Reflections and Observations

The course is deliberately interactive and structured to provide students with a variety of approaches to teaching and learning beyond the familiar lecture format so familiar to engineering students. While the writers advocate for this interactive style of teaching and learning in an engineering school, it is seen as being complementary to the conventional approach. We believe that we must convey the broader impact of social, environmental, and ethical aspects in other courses too, but there is a limit to how far we can go in this direction. Clearly, there will always be a need for formal technical instruction.

Although all engineering students in Canada are required to take a course in technology and society to fulfil their degree requirements, the pre-registration student sentiment towards this course, as with other non-technical courses, varies. Some do not anticipate the course positively, arguing that the objective of an engineering school is to deal only with design, calculation and technical issues. Thus, a major intent of the course is to change that mindset so as to recognize that an engineering student educated only to design and compute is like a medical student who is trained only to treat the body as a machine but has no understanding of the human dimensions of medical practice.

Allowing students to hear their own voices and the voices of others expressing different views throughout the course is as important as the efforts of the instructor in raising issues of technology. Most importantly, they may see that the issues addressed in the course are an essential aspect of engineering practice and that their ability to bridge the gap between engineering and the public is vital, especially as the public is increasingly concerned about the negative impacts of technology." It is hoped that through this course, engineering students will see their ethical obligation to aid in policy making and to play a significant role in public education about technology. Regarding themselves as purely servants of corporations and government is not only demeaning to their profession but a serious loss to society.

In our experience, the mood of the classroom discussions depends very much on the interaction of students. Both the quality of team projects and classroom discussion are strongly influenced by the presence of students who rise up from the student body in the class as leaders. Their inspiration can help other students raise their goals and elevate their level of interest. Without such team leaders, there is slippage in meeting goals and complacency can set in.

Most students were satisfied with the textbook and with the reports but there were also some negative responses. The books "Yes/No" format was generally seen as "helpful." Along with the course facilitators, students found the largest drawback to the book to be the non-uniform writing styles in the chapters, each been written by two different authors. Some writing is very dense and repetitive and in some chapters the distinction between the two sides is not clear. It is hoped the publishers will make improvements in later editions.

IV. STUDENT RESPONSE

At the end of the semester, students completed an in-class evaluation. Students were more interested in working in groups than working individually. 72.5% of students supported in-class group discussions and thought they were valuable because they exposed student to different perspectives. 74.6% of students indicated that the variety of learning environments (lectures, guest speakers, group discussions, essay, and group project) increased learning. 79.4% of students agreed that the out-of-class survey conducted by groups was a valuable exercise for their groups. The great majority agreed or strongly agreed that group work enhanced the course. 68.6% of students agreed that the group project provided them the opportunity to consider issues in depth. 70.0% of students recommended that the short 3- page essay in which student had to "take sides" on an issue definitely motivated them to read more critically and carefully.

V. CONCLUSIONS

Engineers as developers of technology need to develop the ability to think about the broader implications of their technological designs and systems. The structure and format of Technology, Society and the Future course taught at the Faculty of Engineering at the University of Manitoba, has been a successful approach in raising the awareness of engineering students to the impact of technology practice on society and the impact of society on technology practice.

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