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Igniting Creativity and Innovation in Engineering Students: The Case for Technology and Society Courses in Engineering Curricula

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Dr. Chang's current research interests lie in the areas of engineering education and international development. In particular, she is interested in ways to support and enhance diversity in the engineering student population, as well as curriculum development to best prepare students to meet the needs of the green economy. As an extension, she is also exploring ways to engage students in the social side of engineering through community projects. In the field of international development, her primary interests are in safe water supply access, environmental conservation and sustainable livelihoods.

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Abstract: Engineering educators have long struggled with coaxing creativity from their students, given the massive amount of prescriptive material that must be covered in their curricula. If students want to graduate in four years, they have very limited time to explore unique interests outside of their specific engineering discipline. A technology and society course offers a tremendous opportunity to bring in material relevant to engineering students at a personal and professional level, and demonstrates applications of skills they are learning in their quantitative courses. This paper describes such a course taught at the University of Calgary that is structured to motivate innovation and entrepreneurship, and to empower students to envision the positive change they can make with skills they have acquired throughout their education. The course consists of over 120 students from second year to fifth year, from all disciplines of engineering offered at the school. The sheer number and diversity of the students required flexibility in material and assessment. As such, the students were given the open prompt of finding a social problem they care about, and devising a technological solution to address it. They were encouraged to consider their solution all the way to implementation, which would require tasks such as talking to regulators, conducting market research, and running surveys. In addition, the students were coached to consider multiple dimensions of framing an engineering problem and solution, as well as how to pitch their ideas targeting four bottom lines: technical acumen, social benefit, environmental impact, and economic viability. In a course that has traditionally been viewed simply as a necessary requirement, many students came alive. Some students are exploring patent options for their innovations, others soliciting partnerships with sports franchises, and others acquiring summer internships as a result of their projects. This paper presents student assessment on the social dimensions of engineering as well as their ability to make a difference in the world, as a consequence of this course.

In its inception, the field of engineering was defined by creativity and innovation. Monumental changes in human welfare throughout history have been linked to engineering advances, such as the steam engine in the Industrial Revolution and the proliferation of personal computers in the Information Age. Yet paradoxically, traditional engineering education has become prescriptive, hammering students with a slew of equations and rules to solve them. While students have become masters at solving problems with defined parameters similar to those given in their assignments and exams, they become flustered when pushed beyond those comfort zones. Some have argued that this kind of curriculum not only fails to foster creativity, it actually stifles ingenuity[1], inhibiting innovation to solve the world's greatest problems

We sought to reverse this negative association between creativity and engineering education by motivating a large engineering class with a combination of Ethic of Care[2,3,4] and entrepreneurship. Ethic of Care is a concept grounded on value-guided practices to meet the needs of those receiving the care, within a framework of justice and rights[5]. By incorporating a wider view of stakeholders and their relationships in the engineering design process, this combination is able to spark creativity sourced from two distinct avenues: deeply rooted motivations derived from the students' personal values and ethos that is independent of their coursework, versus the excitement of innovation and bringing something new into the world. In terms of concrete parameters for evaluating engineering decisions, Ethic of Care brings to technical requirements the need to examine social and environmental ramifications of engineering design[6]. The entrepreneurship element adds the perspective of economic viability and marketability, which ties engineering back to societal drivers. The ultimate goal is to empower students to feel a sense of agency to make a positive change in their world, despite being students still in the midst of their studies.

This paper describes an innovative technology and society course made up of more than 120 students. The course is designed such that students can explore the creative nature of engineering and are exposed to the multiple facets and hurdles of implementing engineering solutions. The purpose of the course is to encourage the students to apply the skills they have learned thus far in their university education and to explore issues they care about by incorporating their personal values. In contrast to initiatives such as Engineers Without Borders and general engineering programs for green/sustainable design, this course is not elective and thus does not only target a select group of enthusiastic students that choose to partake in social engineering. Rather, the vast majority of the engineering student population at University of Calgary, where this is the most popular course out of three courses that fulfills a degree requirement, is exposed to this methodology. The other two courses are in the process of being phased out and this will be the only course to fulfill the requirement in the near future.

I. Course Design

The course consisted of two 75-minute lectures a week for the entire class, with the class broken up into three 75-minute weekly sections of between 29 to 51 students over the course of a 13-week semester. The goals, or learning outcomes, of the course are to increase the student's ability to 1) evaluate the impact of technology on multiple facets of society such as environment and social norms, 2) identify the impact of social factors such as law and economics on technological trajectories, and 3) devise a technological solution to a social problem by assessing the solution's feasibility and effectiveness, and promote the concept in a dynamic and persuasive manner. Enrollment was opened to second year and older students from all engineering majors offered in the school, though some non-engineering majors did enroll (2%). The sheer number and diversity of the class required flexibility in the material and assessment. As such, the students, in groups of three or four, were given the open-ended prompt of presenting a social problem they care about and devising a technological solution to address it. While the students were not required to come up with a completely new technology, the solution has to be new in the context they want to implement it, e.g. on campus, in the city, province, or country. If the solution has already been implemented elsewhere, they are tasked with taking the extra step to find the requirements for implementing their solution in the locale they have chosen, by talking to stakeholders, policy makers, and other decision makers. The projects were evaluated on four bottom lines: social benefit, environmental impact, economic viability, and technical feasibility, weighted equally. They were asked to carry out market research and gather primary evidence and feedback from their clients as well as seek out expert advice. The students were encouraged to approach their project as if it can become reality rather than simply a project that will end with the term, so it should be something they care about and really think should happen.

To give the student context as to what is possible, two examples from NPR (National Public Radio) were presented, with several lectures devoted on how to frame problems and possible solutions. First, to demonstrate that complex engineering is not required to make a big difference, the students were introduced to a project by Los Angeles artist Mary Beth Heffernan that sought to humanize Ebola health care providers in Liberia[7]. This example dealt with the survival of Ebola patients and how the alien-looking HazMat attired health workers further increased fear in patients facing the deadly disease. To ameliorate this fear, Heffernan decided that Ebola caregivers could be humanized simply by putting a sticker, of the face of the individual wearing the suit, on the outside of the suit. This made a difference not just to the patients but also to the workers themselves by making the caregivers and their colleagues more relatable. While the technology was simple and could be easily implemented in any modern setting, this technology transfer proved difficult in rural Liberia, such as problems with getting the appropriate electrical connections for printers and cameras. This example illustrated for the student the importance of understanding your client's environment and the advantages and barriers it may pose.

The students were asked to first imagine themselves in the role of the patients, living in a rural village with straw thatched homes, facing an epidemic of neighbors dying from an unknown disease. What would be your concern? Your priority? The international community comes to help you. A photograph of aid workers is displayed to the students. How do you feel about their assistance? Do you trust them? What would help to gain your trust?

The second example shown to students dealt with low female school attendance in developing countries. The students were asked: why do you think that is, imagining you are a school age girl in a developing country? While the students identified many possible explanations for this phenomenon, such as the need to stay home to do housework, studies have shown one significant reason is the lack of adequate methods to address menstruation[8,9]. To tackle this problem, there has been a proliferation of innovations in female sanitary napkins in developing countries, such as AFRIpads in Uganda and Sustainable Health Enterprises in Rwanda, which use local materials and local workforce to produce their products[10]. These examples demonstrated the magnitude of human impact via relatively simple technologies, which the students in the class already have the skills to create.

One problem with the aforementioned examples is that they were implemented in developing countries, in an environment where technology penetration is low and simple solutions are sufficient to make significant strides. This is not the case for the student's immediate environment and thus less relatable to them. To demonstrate an example based in our community, I carried out a project on dog waste in preparation for the course. The city of Calgary has 151 dog parks with over 122 thousand dogs in the city, equivalent to one dog for every 10 persons[11]. The students were asked: What are some potential problems for such a dog loving city? Disposal of dog waste is a bylaw of the city, and if one approximates that every dog in the city defecates three times a day and the mass of a single bag is 3 g, that is equivalent to approximately 3500 kg of plastic/day. The feces themselves pollute the environment and contaminate groundwater; the plastic from the bags can take hundreds of years to decompose. How can Calgary decrease its waste from dogs? In Cambridge, Massachusetts, a temporary dog waste digester was installed to generate energy for lighting a dog park[12]. I proposed this idea to city officials, and excited by the idea, they were interested in implementing this concept at a popular local dog park. This dog park's parking lot has had problems with car break-ins, and the city had been exploring lighting options for the lot, which the digester can conveniently fuel. As a consequence of preparing for this course, the city of Calgary is on its way to reduce dog waste and deterring crime at their dog park by installing a waste-to-energy digester.

The students found this example inspiring and began to appreciate the possibilities for their own projects. Sections in the first two weeks were devoted to project development, where the teaching assistants helped individual groups frame the problem they'd like to solve, ask appropriate questions that target the four bottom lines, and come up with possible solutions. Each group was required to discuss their idea and explore possible gaps in their thinking with me at least once before their presentation in a 30-minute meeting. With two lectures spent on human-centered design thinking[13], 39 group projects resulted in areas of health, social welfare, waste, transportation, energy, and water to be launched on the university campus, in the city, the province, the country, or internationally. In their sections, each group had 15 minutes to present their social problem and solution with an additional five minutes allocated at the end of the presentation for Q&A. Each group was also tasked with producing a marketing poster for their project to highlight their problem and solution. The students were given freedom as to the specific content and layout of the poster, so long as it effectively advertised their solution. The posters were hung throughout the engineering building so the general student population could peruse what their peers had come up with and the students in the class could be proud of their achievements. Three projects were presented during each section, and the students in the section voted on the top project from each session. From this, 13 projects plus two wildcards selected by the teaching assistants were moved to a second round, where each group presented a 3-minute pitch to a panel of three external judges. After the pitches, the judges had 30 minutes to examine each group's poster and to probe the students deeper on their projects. The top five groups received a free private consultation session with a local start-up incubator to explore ways to extend their idea and discuss potential business opportunities that can be derived from their projects.

Student reaction during this process reinforced the stifling of creativity endemic to engineering education at our university. One student in particular was very flustered because she was "not used to having to be creative in school" and did not know how to approach the assignment. As the instructor, I responded by asking her to look in her own life outside of school to find ideas, as it should be something that she cares about beyond the classroom. Several student groups expressed that their projects were something they have thought about for a long time and have wanted to implement, but never had a venue to explore given their busy academic schedules. A common reaction among the students was the surprise they felt that they could actually make a difference, even though they do not have advanced degrees and years of business experience. Some students very much took to heart that their idea can turn into reality, and created simple prototypes to demonstrate its feasibility, talked to potential sponsors, and explored patenting options.

II. Student Projects

The 39 projects completed by students during the semester can be broken down into four categories: product (46%), service (15%), space (3%), and system (36%) (See Appendix I for example projects). Product is what people generally think of for engineering design, and in this case means a physical object that performs specific tasks. Some products proposed included innovations such as a wristband that can measure heart rhythm anomalies and send emergency SMS to medics, guns that will only fire with owner fingerprint validation, and cheap and portable bedding for the homeless. For the category of service, many student groups proposed smartphone apps, such as helping smokers quit, connecting refugees with locals for jobs, and recycling sand and gravel from road maintenance during the winter. The third category, space, can give important signals on how people need to change their behavior for a particular end goal. Only one student group attempted to create a project in this category, with a proposal to implement a traffic waiting zone at a particular intersection in Calgary, a practice that was piloted in China. Lastly, the most complex category, system, takes into account various stakeholders with different needs and consists of multiple steps to achieve their goals. System projects included an idea for rapid-prototype (RP) arms for amputees in developing countries in collaboration with the Red Cross, supported by revenue generated from RP fashion in the developed world, and a system of reusable dishes in the student food court which would require vendor buy-in and new space allocated for dish washing.

III. Student Assessments and Impacts

Student responses indicated that the majority experienced a favorable increase in outlook on the impact of engineering on social welfare. At the end of the semester, surveys were given to the students to gain feedback on learning outcomes and how the course can be improved. In lecture, we focused our discussions on the consequences of technology on society, with numerous guest speakers from outside academia as well as ones that dealt with technology from outside engineering, people the students are not typically exposed to in their other classes. Much of the course was focused on their projects, whether it was lectures on human centered design or discussing case studies together as an entire class, and the sections were completely devoted to their projects. The students were asked what they thought about the project set up, as well as specific questions to elicit feedback on their change in perception as a consequence of the course. The surveys were anonymous to obtain honest feedback.

One of the primary goals of this course was for the students to gain greater understanding of the social dimension of technology. They were asked to rate the statement "I have a better understanding of the social dimension of engineering as a consequence of this course" with: 1 (not at all), 2 (very little), 3 (some), 4 (quite a bit), and 5 (definitely). The baseline is set at 1 meaning no increase in understanding, assuming nobody felt they had *less* understanding as a consequence of this course. In addition, space was provided for the students to specify "in what way(s)". From the 98 responses, the mean was 3.35 with a standard error of 0.12 (see Figure 1 and Table 1). 72% of the students elaborated on their numerical response, which included statements like "thinking about how engineering really applies to real world technological applications" and "my actions as an engineer have the ability to change lives."

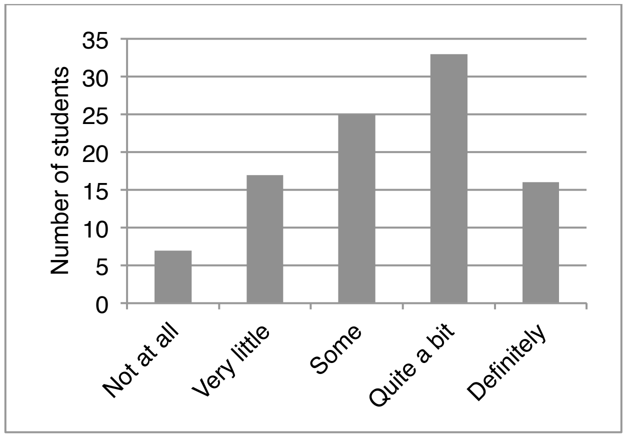

Figure 1: Distribution of student response to the statement: “I have a better understanding of the social dimension of engineering as a consequence of the course”.

Similarly, the students were asked to rank the statement “As a consequence of this class, I feel more empowered to make a positive difference in the world.” The baseline is set at 1 meaning they felt the same as they did prior to the class in terms of their ability to make a difference. The 99 responses resulted in a mean of 3.35 with a standard error of 0.12 as well (see Figure 2 and Table 1). For the 76% of the students that elaborated on the follow up question to this rating, “what element(s) of the class made you feel this way,” they felt the discussions in lectures as well as their projects contributed to their growth. Others commented that the class reaffirmed their belief that it is a part of the engineer’s role to make a positive difference in the world.

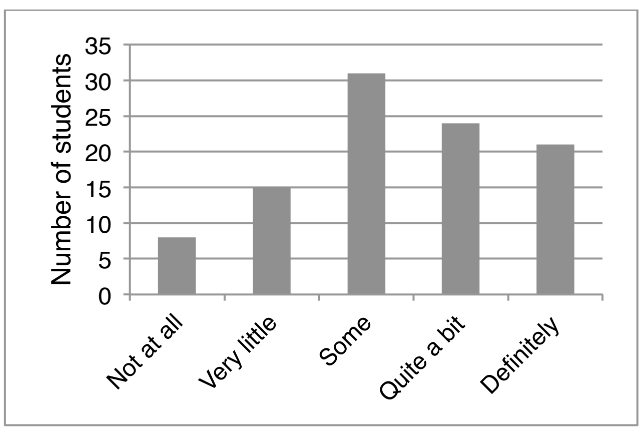

Figure 2: Distribution of student response to the statement: “As a consequence of this class, I feel more empowered to make a positive difference in the world.”

Question	Number of Respondents	Mean	Standard Error of the Mean
I have a better understanding of the social dimension of engineering as a consequence of this course.	98	3.35	0.12
As a consequence of this class, I feel more empowered to make a positive difference in the world.	99	3.35	0.12

Table 1: Student responses.

Finally, the students were asked if the class changed their perspective/goals/behavior in any way. For the 55 students that answered affirmative to this question (equivalent to 65% of the students that answered the question), their responses can be divided into four main categories: 1) Increased self-awareness, 2) Redefined role of engineers, 3) Broadened career options as an engineer, and 4) Motivated drive to make a difference. For the first category, we talked in lecture extensively about the pervasiveness of technology in our daily lives, and how unconscious and insidious (e.g. cell phones and social media) as well as tremendously beneficial (e.g. medicine and transport) that enmeshment can be. Some students responded that they have changed their phone usage because of what they learned in the class and as a consequence increased their productivity and sleep time. Other students reflected on how their projects have made them much more mindful of their personal contribution to their project topic, such as waste disposal. In his/her internship, one student stated that s/he "now always think[s] about the social and environmental consequences of the work I do." By supporting the students' qualitative comments with quantitative results, the survey was able to demonstrate that the course succeeded in achieving its objectives.

For some students, their view on the role of engineers in society has shifted as a consequence of the class, while for others, it reaffirmed why they choose to be engineers in the first place. One student responded to the question with: "It makes me proud to be in engineering because of the difference we can make." Several students said the course added to their knowledge of the social side of engineering, that engineering is much more than the technical and numbers, which is easy to lose sight of since that is the vast majority of the focus in their curriculum. The students appreciated seeing that engineers could make an impact on social problems, something highlighted in the course both in lecture as well as through student projects. For the third category, a portion of the students expressed a greater awareness on the broad range of professional options for an engineer. In lectures, I brought in engineers who work in the non-profit sector and start ups, very different from the dominant local industry of oil and gas where a large portion of our students ends up. Several students stated they have become much more dedicated to sustainability in their fields and others have found their passion in renewable energy as a consequence of the course. Lastly, a group of students responded that they felt more ambitious and wanted to make a difference in the world through their chosen field. The course showed them that it is possible to make significant impact with enough commitment, and that everyone has the potential to make a difference.

IV. Transferability/Limitations

Many of the strategies implemented in this course, whether it is a diversity of guest speakers or the project prompt, can easily be replicated in other settings, as they are not unique to our institution. One advantage we have is access to an innovation incubator whose mandate is to support the university. The opportunity to consult with staff at the incubator served as an incentive for the students to work hard on their projects by having experienced advisors guide their projects into reality. To create a similar incentive where an incubator is not available, this can be substituted with local corporate/business mentorship that may be available in the community, or potential collaboration with remote incubators through videoconferencing. The significant contrast between this course and the vast majority of required engineering courses at this university also contributed to the success of the course. In a setting where engineering curriculum includes many liberal arts courses, a rare scenario in large public institutions, this type of course may not be as impactful.

V. Conclusion

At the University of Calgary, a technology and society course for over 120 students was designed to inform students of the social side of engineering, to generate student excitement for their chosen profession, and to challenge them to innovate by combining Ethic of Care and entrepreneurship. Though the course was large, it was designed such that each student group received individualized attention from both their TAs and their instructor. The range of projects that came out of this course varied widely due to the diversity of student academic backgrounds, and in general, the student responses demonstrated positive learning outcomes per the goals set out at the commencement of the class.

This case study demonstrates a compelling case for technology and society courses in engineering curricula, which sparked creativity, innovation, and excitement in the engineering students at the University of Calgary. As engineering educators, our ultimate goal is to inspire and motivate students to innovate with their unique visions. The course achieved this goal by showing students examples of the significant impacts of relatively simple technologies, well within the scope of their abilities, or if not, accessible through thoughtful research and guidance. The students, galvanized by their personal passions and the opportunity to exercise their creativity, were able to design projects that reflect the energy they devoted to the class and the potential for their far-reaching impact to make the world a better place.

Appendix I: Example Student Projects

The projects described here are work completed over a single 13-week semester. The narrative expands on the motivation of each student group, the details of their design, and anticipated future steps. Each project reflects the evaluation criteria as outlined above in the "Course Design" section.

A. Reusable Dining Ware for Student Food Court

A group of three third-year students from civil engineering, chemical engineering, and biology devised a project to implement reusable dinnerware for the student food court, which has a similar set up as a mall food court with several external vendors around a central eating area. The significant advantage for the group is that the Student Union (SU) owns the facility and has decision-making power. The SU already has strong sustainability initiatives in place, such as using cardboard clamshells and promotion of proper disposal like recycling and local composting.

After studying the policies of the food court, the group decided on a system where students would sign up to receive a membership card, which they then would exchange for dinnerware at a designated booth. Students would then bring the dishes to the vendors for a discount on their food. After the meal is finished, the student would return the dishes in exchange for their membership card, and they would earn points in a reward system. The dishes would be washed and processed by volunteers or paid interns. One important criterion for the team was that they wanted to advocate a solution that has been proven feasible and can make a significant impact on waste reduction. They were able to find several universities that implemented successful systems resembling their solution, which gave them hope that it can be executed here.

Talking to the facility director of the food court brought to reality the limitations of their proposal, given the facility currently does not have enough dishwashing capacity to handle the volume their solution would generate. He suggested that a food vendor would have to be replaced with a dishwashing facility in order to accommodate the increase in load. The group outlined next steps for the proposal, such as talking to vendors, securing funding, finding a supplier for the reusable dinnerware, identifying a location for distribution and washing dishes, and recruiting staff for washing dishes.

The group also carried out an economic analysis to demonstrate that reusables such as plastic and ceramics would be a significant cost savings compared to compostables, and proposed financing options through university grants and partnerships with local environmental groups and firms. Their hope was to roll this system out in our university, then to other universities in the area, and eventually to universities nation-wide. The goal was to change the social norm of a disposable society, divert thousands of pounds of waste from landfills, and generate conversation about food packaging and alternatives.

As one of the groups that ranked in the top five, they met with advisors from the start up incubator to assess next steps for actualizing their plan. The advisors helped the students clarify their goals, what they would consider for profit margins, and what resources they may have access to as they move forward towards implementation. To quantify the kind of discount the vendors could realistically offer, the advisors suggested the group to ask every vendor how much they spend on disposable dishware and cutlery, and how much they would be willing to offer in discount if this cost was to be removed from their budget. The group has been excited by the support they had received from the SU, who, as the owner of the student hall, could dictate a wholesale shift in dinnerware strategy to their tenants/vendors. The advisors also suggested the group to track all of their costs so they can present a complete plan to the SU, and explicitly articulate value propositions for each stakeholder such as the university, SU, vendors, and students. The group was also advised to conduct a survey to assess student's willingness to pay for the membership cards and discount level required to offset the inconvenience of reusable plates. With a concrete path forward, the students hope to begin implementation in the next academic year.

B. Piezoelectric Tile Installation

A group made up of two fourth-years in civil engineering, one fourth-year in electrical engineering, and a second-year in mechanical engineering was interested in investigating renewable energy because of their concern for global warming. At the university, 90% of the electric power is generated from fossil fuels, resulting in CO_2 emissions weighing the equivalent of 364 Boeing 747s a year, and the group wanted to make an impact on something that the student body can relate to and get excited about. Taking advantage of the stipulation that they can propose a tried solution but implement it in a new setting, the students came up with the idea of installing piezoelectric tiles on campus. This material turns kinetic energy into electrical energy when a special quartz crystal material embedded in the tile is compressed, twisted, or pulled. According to the firm that produce these tiles, each step can generate 8 W of electrical energy for external use.

The group decided on this project because of its feasibility, as the technology is commercially available and has been installed in places such as Heathrow Airport in London and Federation Square in Melbourne. Located between the university food court and the science and engineering departments, the team identified a corridor that funnels people into a small area. This corridor is the only indoor path between the two areas, making it highly trafficked, particularly in the winter. The appeal for the team was that if the university decides to invest in solar energy, the piezoelectric energy extracted from foot traffic would be highest during the winter months when solar energy is the least available, thereby providing a good complement to potential future development.

To assess how much energy can be extracted, the students counted foot traffic during peak and off-peak hours, and conducted surveys of student attitude on such an installation. They received very positive responses from talking to students, though most people had not heard of the technology. The team mapped out a pilot study, which entails installing eight modular tiles in a small segment of the corridor with ramps to accommodate wheelchair accessibility, to test out user response and actual energy returns. Calculations based on their analysis showed that energy generated from their pilot should result in a reduction of 29.1 tonnes of CO_2 a year and power 12 refrigerated vending machines for a year. In addition, the students calculated the initial capital cost, maintenance cost, and the savings from electricity generated to show cost recovery in three years. The group talked to the university's sustainability department for facilities management and they expressed interest in the students' proposal. They were told that multiple university, municipal, and federal grants would fit the scope of their project which they should pursue. The next step is for the team to develop a business plan, and if the university finds the plan compelling, it may self-fund the full scale.

The students were very excited and at the end of the term were in the process of applying for a university grant for this project. They were contacting the vendors to get an accurate estimate of cost, though struggled to find the required time on top of their coursework. They would like to pursue this project beyond the class, time permitting, with a goal of ultimately implementing the full-scale installation and generating conversation amongst the students on the issue of renewable energy, which the tiles would instigate.

C. Reusable Cups for Local Stadium

A fourth-year in chemical engineering, mechanical engineering, and a second-year in civil engineering formed a team that sought a problem big enough to be meaningful but small enough to be manageable. In 2007, the city council of Calgary set a goal of diverting 80% of waste from its landfills by 2020. There have been multiple initiatives throughout the city to achieve this, but they have been predominately in the residential sector, with significant potential in the industrial, commercial, and institutional sectors remaining. In fact, waste per capita has actually been increasing in the past three years, and city officials have already declared defeat on their 2007 goal. The students wanted to find a problem with a local focus, since they intended to implement and make into reality their solution.

To help the city mitigate this failure, the group came up with the idea of using reusable cups at the local stadium. One of the group members had seen this in practice at European stadiums, and saw no reason why it should not work in our local stadium. To assess the possibility of implementing their solution, the students went to the stadium during a game with a questionnaire based on their proposal and surveyed concession sales people, staff throughout the facility, and attendees.

At the time of the project, one of the students was interning at a company that had assisted the stadium during its reconstruction, and his boss had contacts with the senior management of the sports team that owns the stadium. The student team was then able to meet the sports team's Business Analyst, the VP of Food and Beverage, as well as the Safety Coordinator. They delivered their class presentation to these managers and received a very positive response, especially since management had not considered the idea before. The students proposed a system of paying a $2 deposit for a reusable polypropylene cup during games, which would then be reimbursed upon the return of the cup. The group researched possible suppliers for the cups and the dishwashers. They also estimated cost savings and waste diverted if their strategy is implemented, which may be significant considering 3.2 million disposable cups are used every year at the stadium.

The management and event attendees they surveyed were concerned about the long lines that may result when people are returning their cups for reimbursement, as well as the lack of space for dishwashers. The students said they would explore these concerns, and given this was a practice implemented during the World Cup, the first issue should be manageable and the second may require creative solutions like a portable dishwashing facility. The management has expressed interest to meet the students again once they have identified concrete solutions to these challenges and addressed their concerns.

The group is very keen on their project and has taken active steps to pursue it further. They believe the positive impact and cost savings of this solution make its implementation inevitable, and they want to be a part of that process. They were one of the top five groups and have also received mentorship from the startup incubator. The advisors from the incubator discussed a possible business plan for creating a reusable cup for stadium use service. They noted the enterprise is capital intensive and asked the group to consider ways to minimize the initial cost. The students were asked to think about their enterprise more broadly and consider the local stadium as their first rollout versus catering to the specifics of this stadium. As with the other group, the advisors requested them to outline the value proposition for all the stakeholders to justify their expenditure and plan for future investors.

D. Heart Alarm

Three mechanical engineering third-year students formed a group to find a solution for decreasing heart disease mortality. One member of the group recently had a family member pass away due to cardiac failure in his sleep. She reflected that if the medic was alerted promptly, he may still be alive today. The group found that cardiac arrest occurs most often when people are alone and do not have the ability to call 911. For a tool to be effective, connecting to the medic must be automated. The team explored current solutions in the market, which included biofeedback wearable devices that can contact family members or a call center.

As they discovered through their research, the probability of survival from cardiac arrest quickly diminishes as the wait until defibrillation increases. The goal of the group was to get emergency medical services as fast as possible, and thus requiring bypassing the intermediate steps, such as contacting a call center, instituted in the currently commercially available devices. After conducting surveys of seniors and people at risk for cardiac events, the team came up with the solution of a wearable bracelet that would monitor heart rhythm continuously, and send an emergency text message to 911 in the event of cardiac rest or heart rate anomaly beyond a defined threshold. This is possible because all that is required is a cell phone antennae, as emergency calls/texts are free so no service plan is necessary. They recognized the efficacy of their product was dependent on having cellphone connectivity and accurate sensors, as well as challenges that it faced with potential false positives.

The students talked to three doctors about their idea, and some were enthusiastic about their idea enough to suggest summer internships at their clinics to work on this project. At the end of the term, the students were exploring patenting options, evaluating their summer options, and considering the possibility of doing research on this project.

E. eyeTracker Pro

Three mechanical engineering fourth-year students proposed a device that will track driver's eye movement, to be mounted on the windshield. If the device sensed the driver's eyes are not within a predefined field of view such as out the front windshield or out the side windows, an alarm would be triggered to alert the driver to return his/her attention back to the road. The team surveyed devices that were already on the market that serve this purpose and found them to be expensive. They believed their solution will be more cost effective, and proposed partnering with insurance companies to create adoption incentives. The product would be connected to a Bluetooth device which would record the number of times the alarm was triggered, and drivers with low numbers of triggers would be rewarded with lower insurance premiums.

The students interviewed numerous truck drivers and commuters to get their perspectives and adjusted their design to suit the concerns. They believed the concept is technically feasible, but none of them have the electronics background to turn this concept into reality on their own. Towards the end of the semester, the students were focused on finding employment so did not have the time in the immediate future to pursue this project. However, they relayed examples of applying the lessons they learned from the course to their own lives. For example, one student was interning at an HVAC company. Prior to the class, he had always looked at problems just from the technical perspective, but now he also considers them from the user and social perspectives as well. He described a product his company is piloting that, if successful, will require less human labor. Prior to the class, he would not have thought beyond this, but now he is aware that the success of the product will mean lost jobs for people. So while the group is not looking to continue their project immediately, they are taking important lessons they learned and incorporating them into their lives.

Appendix 2: Course Syllabus

1. Calendar Information

---- Technology and Society

An interdisciplinary course that delves into the relationship between technology and society. The impact of technology from the perspectives of engineering, law, business, sociology, history, and social justice will be presented. Technology in energy, social media, medicine, education, surveillance, and others will be discussed.
Course Hours: H(3-3/2S)
Calendar Reference: -----

2. Learning Outcomes

At the end of this course, you will be able to:

1. Evaluate the impact of technology on multiple facets of society such as the environment and social norms;
2. Identify the impact of social factors such as law and economics that impact technological trajectories;
3. Devise a technological solution to a social problem, to assess the solutions feasibility and effectiveness, and promote the concept in a dynamic and persuasive manner;
4. Investigate a critical issue in technology and society centered on a specific book and extended through literature review

3. Timetable

Section	Days of the Week	Start Time	Duration (Minutes)	Location
L01	TuTh	18:00	75	ST 148
T01	M	17:00	75	EEEL 210
T02	W	18:00	75	EEEL 210
T03	F	16:00	75	EEEL 210

4. Course Instructors

Course Coordinator

Section	Name	Phone	Office	Email
L01	------	------	MEB 214	------

Teaching Assistants

Name	Office	Email
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5. Presentations and Essays

In groups of three, students will be have the opportunity to devise a technological solution to a social issue. Examples of this will be presented in class. More details can be found on the course website on D2L.

Students will also write an essay, no longer than 1500 words, based on one book listed in this course outline. More details can be found on the course website on D2L.

6. Class Participation

Attendance and participation in at least 1) 24 lectures, 2) three seminar tutorials (Week 4 through 10) in addition to their own, and 3) one preparatory tutorial (Week 2 and 3) are required. Participation includes contributing in discussions, answering questions, asking questions, and taking part in surveys in class. The quality and the extent of participation will be assessed.

7. Final Grade Determination

The final grade in this course will be based on the following components:

Component	Weight
Class Participation	30 %
Presentation	35 %
Essay	35 %
	100 %

Notes:

a) Conversion from a score out of 100 to a letter grade will be done using a scale determined after the final examination has been marked. This allows the creation of a scale appropriate to the relative difficulty or easiness of the term work and the final exam.

8. Textbook

One of the following books is required for the course:

- Guns, Germs, and Steel by Jared Diamond
- Lost History: The Enduing Legacy of Muslim Scientists, Thinkers, and Artists by Michael H. Morgan
- Death by Design: Science, Technology and Engineering in Nazi Germany by Eric Katz
- Machines of Loving Grace: The Quest for Common Ground Between Humans and Robots by John Markoff
- The Immortal Life of Henrietta Lacks by Rebecca Skloot
- The Circle by Dave Eggers
- Alone Together by Sherry Turkle

9. Course Policies

[…]

10. Additional Course Information

[…]

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