HUMANITARIAN ENGINEERING: A NEW INTERDISCIPLINARY COURSE ON THE APPLICATION OF ENGINEERING SKILLS TO LOCAL AND GLOBAL HUMANITARIAN CHALLENGES

Andrew Sheroubi and Gabriel Potvin

Department of Chemical and Biological Engineering, University of British Columbia

a.sheroubi@alumni.ubc.ca and gabriel.potvin@ubc.ca

Abstract – *Many students express a desire to apply their technical engineering skills to produce positive societal impacts, and although sustainability frameworks do take this into consideration in traditional engineering curricula, there are relatively few avenues for students to work on real global social issues during their undergraduate studies. This paper describes a new interdisciplinary course developed at UBC on the use of engineering skills to solve humanitarian challenges.*

The course is composed of case-study analyses, interactive activities and simulations, group discussions and seminars, and a technical design project completed in partnership with an NGO or charity working on a particular humanitarian challenge. The rationale and design of the course and its deliverables, as well as student feedback on this first iteration of this course are presented.

Keywords: Interdisciplinary education, humanitarian engineering, experiential learning, peer teaching

1. INTRODUCTION

Engineering education, across all disciplines, focuses primarily (and understandably) on the development and application of scientific and technical design skills. There is, however, a growing recognition of the importance of developing more globally-minded and well-rounded engineers, and many students express a strong desire to find ways to apply their skills to produce positive societal impacts, but struggle to find appropriate avenues to pursue these ideas as part of their studies [2]. There is therefore an underserved demand for opportunities to bridge technical elements and their application in “real-world” global contexts. One such context that is rarely covered in traditional curricula, but which presents particular challenges and unique opportunities for engineers, is the application of engineering skills to humanitarian aid scenarios [1,5,7].

Humanitarian aid projects are in many ways similar to engineering design problems, in that they are open-ended and consist of complex combinations of objectives and constraints, stakeholders, systems, and environments, but are different from engineering problems in that they involve a lot more of the “human element”, as opposed to technical considerations, than engineering students are trained to consider. This unique complexity presents an opportunity to train students in dealing with humanitarian projects, making them better engineers and global citizens, while also continuing to hone their more traditional technical problem-solving and design abilities.

This paper describes a new upper-year, project-based interdisciplinary engineering course that explores humanitarian issues and how engineers can apply their skills to contribute to their resolution. The overarching goals of this course are to introduce engineering students to humanitarianism from both social and technical perspectives, and provide them with the tools and resources necessary to pursue humanitarian engineering as a career or incorporate humanitarian thinking in their work. The course covers responsible, sustainable aid and provides an avenue for engineering students to engage in humanitarian and social issues. The course has three primary objectives:

1. Develop a methodological framework to analyze local and global humanitarian issues by identifying their root causes and context, as well as procedures for recognizing and validating assumptions made throughout this process.
2. Apply engineering knowledge and skills to a real-world humanitarian problem through a technical design project, considering complex social factors and the unique needs of stakeholders, all in collaboration with NGOs.
3. Examine the role of the engineering profession globally and identify opportunities to improve

human welfare through the application of technical skills.

This course is developed under the Student Directed Seminars program at the University of British Columbia [10]. The course ran from January - April, 2018 and was composed of 15 upper year students from a range of programs (chemical and biological engineering, electrical engineering, geological engineering, engineering physics, and geophysics programs), selected from a pool of applicants based on submitted personal statements. This paper presents the structure of the course and its key deliverables, as well as student feedback on their experience.

2. COURSE STRUCTURE

This course ran for 13 weeks, with weekly 3-hour sessions. Classes were composed of a mix of lecture-style presentations, guest speakers, group discussions, and experiential simulations/activities. Students took an active role in the delivery of the course to enhance the learning experience. An overview of the sessions is shown in Table 1.

The course began by exploring various philosophies related to humanitarianism and examining the major global humanitarian issues using the UN Sustainable Development Goals as a guide. The structure of humanitarian aid and its failures were then examined with particular emphasis on technical engineering considerations. This general discussion was followed by three, two-week technical modules covering water, energy, and food security, with the topics selected based on the interests of the students registered in the course, and each of these modules became the focus of a student team's design project. Each module consisted of a session dedicated to a guest lecture introducing the important technical aspects of the issue, and a session focusing on the social and contextual aspects involved. For part of the second session of a module, teams were asked to present to the class the interplay between technical and social challenges around a case related to the main module topic. Finally the course concluded with tangible steps students could take towards getting involved in humanitarian work, or to implement humanitarian thinking in their engineering designs.

2.1 Lecture Format

Each class was composed of workshops, role-playing scenarios and simulations, group discussions, case-study analyses, and/or guest lectures by technical disciplinary experts (for the food, water and energy security modules), humanitarian workers, and disaster management engineers. The workshops and simulations, designed primarily based on Kolb's experiential learning cycle

developed to induce a perspective shift rather than just convey information [6], were used to explore the relevant social and emotional dimensions of the particular humanitarian challenges covered, to develop empathy, and attempt to bridge the gap between the students in the class and the beneficiaries of humanitarian assistance.

Table 1: General course outline

Theme	Description	
Broad Overview	Week 1-2	Introduction; Overview of Global Issues (utilizing UN's SDG's); & Humanitarian Aid Structure
	Week 3	Humanitarian Engineering Failures & Shortcomings of Aid
Technical Modules	Week 4-9	<i>Water, Energy, & Food Security</i> (2 weeks ea.) Technical & Contextual (socioeconomic) Considerations
	Week 10	Systems Mapping & Stakeholder Analysis
Social Skill Development	Week 11	Disaster Management for Engineers
	Week 12	Design Project Presentations & Monitoring and Evaluation
	Week 13	Project Review & Methodology for Responsible Projects

Most classes were designed partially as Team-Based Learning sessions, and involved facilitated and mediated discussions based on assigned readings, rather than direct instruction. In some sessions students worked in teams to apply learning to a real-world case-study or problems, followed by discussions in larger groups.

2.2 Student Involvement

Given the nature of the course, significantly more flexibility was possible than in traditional classes, and students were encouraged to actively contribute to develop and modify the structure and organization of the course. This typically took the form of input into the content of lectures and topics to cover, as well as in the development of the grading scheme for different deliverables. Rubrics were discussed before each assignment, and students were reasonable (and in fact quite rigorous) in what they considered to be fair assessments. The case study, group presentation, and tangible steps assignment were peer- marked based on those rubrics (the final project was marked by technical professors). As further discussed in section 4 of this paper this democratic format and the resulting increase in “ownership” of the students of the class material contributed to overall engagement.

Students also very much appreciated the multi-disciplinarity of the course and the opportunity to work with people from other programs. Given the effectiveness of peer learning methods [3,8] and the unique opportunity for interdisciplinary work, the course was designed so that each session included active discussions and at least one collaborative activity.

3. DELIVERABLES

A summary of the main course deliverables and mark breakdown, as given to students in the course syllabus, is presented in Table 2, and further described below.

3.1 Case Study

Students were tasked with researching a specific humanitarian case related to one of the technical modules. Each case had to include a specific location along with necessary background information, and a brief overview of past and ongoing humanitarian interventions. The page limit was restrictive for this assignment and its content open-ended forcing students to focus on major themes and convey the information concisely.

3.2 Group Presentation

In their design project teams, students had to prepare and deliver a one-hour long presentation on the subject of their design project and particular assigned humanitarian challenge, covering both the technical and social aspects of the issue. The goal was for this presentation, early in the term, to promote interdisciplinary collaboration and peer teaching within each team before tackling the more demanding design deliverables of the project.

Table 2: Deliverables

Assignment	Due	Brief Description	Value
Case Study	Week 3	Research and condense a topic into one case study relating to a humanitarian engineering failure which will be shared with the rest of the class	15 %
Group Presentation	Weeks 5, 7 & 9	Present and facilitate a class discussion regarding the technical and social aspects around the humanitarian topic of the group’s project.	15 %
Tangible Steps Assignment	Week 13	One page memo recommending one possible avenue to apply knowledge learned in the course	8 %
Participation	n/a	Based on attendance and participation in discussions	12 %
Design Project	Week 13	Design a solution to address a problem statement provided by a partner organization relating to one of the technical modules	50 %

3.3 Tangible Steps Assignment

Individually, students were tasked with writing a one-page memo recommending possible avenues to apply knowledge learned in the course. They were asked to pick only one or two areas of focus, with emphasis placed on the thoughtfulness and quality of the recommendations. This assignment helps ensure that the learning can be applied or further developed beyond the course.

3.4 Participation

Beyond the standard assessment for participation, students were tasked with completing a weekly reflection after each session on what was covered and what the students would like to learn more about. The goal is to reinforce learning, as students that actively reflect on their learning showcase better retention [6].

3.5 Design Project

Working in teams of five, students designed a solution to a real-world humanitarian issue related to one of the technical modules. These issues were provided in the form of problem statements by non-profit or charity organizations with which the course had partnered. Each team analyzed and wrote a case study about the issue in the region where the organization operates and designed an engineering solution to address the specifics of the problem statement. The objective of this assignment was to situate the learning in a real life context to showcase the complexity of this field. Students can gain a more global perspective, navigate more complex systems, and develop a more “empathetic approach to design” by immersion in community engagement projects [4]. Although the problem statements are not presented here, the authors are happy to share any material related to this course that may be of interest to the readers.

4. STUDENT FEEDBACK

Student feedback was collected via an anonymous online survey composed of 11 Likert-scale questions, 14 open-text short-answer questions, and one modified polar question. This analysis captures the responses from the 14 students who filled out the form (out of the 15 enrolled in the course). Some of the more relevant feedback is presented here, but the full data set, which is available to interested readers upon request, will be used to improve future iterations of the course.

Students were asked to indicate the extent to which they found the course interesting and challenging. The results are found in Figure 2. Most students reported they found the course to be very interesting, and in follow-up open-text questions many commented how this course was different from any other course they had previously taken during their undergraduate studies, which further supports the fact that the topic of humanitarian and social work is not extensively covered in the engineering curriculum.

Although the students found the course to be interesting, most report they did not think it was very challenging. Based on the provided feedback, this is primarily due to the wide range of topics that were covered in the course and the resulting lack of depth with

which some of the material was covered. Some students mentioned that they would have liked to take deeper dives on some of the topics, and gain more practice with some of the skills and tools presented. Some of the comments suggest, however, that some students conflated the workload associated with this course with the word “challenging”, and given the discursive nature of the course as well as the traditionally demanding technical engineering curriculum, the level of challenge may be underestimated from these results.

Figure 1: Student responses to the interval questions: “From your perspective how (variable) was the subject material?” (1-very dull; 10 - very interesting)

Students were then asked to comment on the format of the lectures, specifically on the effectiveness of the simulations and in-class activities, as well as the course assignments as teaching tools. The results are shown in Figure 2. Overall students indicated the simulations and activities were useful, although a wide distribution in scores is observed, with two students strongly disagreeing these had any value. In follow-up comments, a few students indicated they would have benefitted from a more solid theoretical grounding before the lecture and would have preferred to receive more preparatory material before attending classes. Several students also indicated they would have liked to incorporate more technical content into the course. Given that technical design is only one of the course objectives however, in future iterations of the course, the focus on the social and humanitarian aspects of engineering problems will be more clearly presented from its onset.

In terms of assignments, most students found the case study assignment to be useful, but some students did display a bit of pushback. Students had a very positive reaction to the group presentation assignment and the design project. Overall, as Figure 2 shows, the students indicated that the assignment enhanced their learning.

One of the main challenges of this course was interacting with the NGO partners, with 43% of students reporting the organization did not deliver the required material or information without significant coaxing (data

not shown). To compound the problem, one partner organization decided they no longer needed the design team halfway through the term, discontinuing their participation in the course, and another team determined, after discussion with field workers and analyzing the data provided, that their partnered organization's problem did not exist, and that they were asked to provide a design that would never be implemented or considered. The partner organizations will be more carefully screened in future iterations of the course to avoid this type of situation.

Figure 2: Student responses to the interval questions: Orange - “The (variable) enhanced the learning process.” (1 - strongly disagree; 10 - strongly agree). Blue – course assignments, orange – activities/simulations.

Students were finally asked whether they would recommend this course to other students, and the data is shown in Figure 3. 64% said that they would recommend the course in its current form, and none said they wouldn't recommend it. From the remaining 36%, 14.4% would recommend this course if the design project could be kept within the same format and improved; 14.4% indicated their recommendations would be conditional on the basis of elements unrelated to the course content; and 7.2% indicated they would recommend it if its technical content was increased.

When asked to comment on their reasons for recommending the course, students mentioned that they thought the course was very interesting and inspiring. Some of the comments capture what the course was striving to achieve, both in terms of student engagement and active learning:

“Probably the best course I have taken at UBC. It is interesting, engaging, and challenging without being too overwhelming.”

Figure 3: Student responses to the modified polar question: “Would you recommend this course to a friend?”

“This is one of the most useful courses I have taken in university. The active learning through discussions and projects really made this a meaningful and memorable course, helping me to grow as a critical thinker and an engineering student.”

“Consistently stimulating; partially responsible for inspiring me to become seriously interested in pursuing a career in pursuing humanitarian action and working in the social sector.”

The full survey data set, along with all of the provided student feedback, is available to interested readers.

5. CONCLUSIONS & RECOMMENDATIONS

This paper describes a new, upper year, project-based interdisciplinary course that aims to introduce engineering students to the context and underlying factors behind humanitarian issues and provide them with an avenue to apply their technical knowledge towards addressing those problems. The feedback from students was very positive and validated the demand for this topic in the curriculum. Based on the provided feedback, the scope of the course should be limited in the future to allow for a more in-depth look at some of the topics. This would likely take the form of only covering two technical modules instead of three, and perhaps to focus on either engineering in emergencies or in development settings. The most effective elements of this course were the community partnership design project as well as discussions and case-based in-class activities, all of which should be maintained in future iterations.

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References

- [1] Bernard Amadei, Robyn Sandekian, and Evan Thomas, "A Model for Sustainable Humanitarian Engineering Projects" *Sustainability*, vol. 1 no. 4, 2009.
- [2] Bernard Amadei, and Robyn Sandekian "Model of Integrating humanitarian Development into Engineering Education", *J. Prof. Issues Eng. Ed. Practice*, vol. 136, no. 2, 2010.
- [3] Seema Daud, Abdul M. Chaudhry, and Syeda Ali, "Lecture Based Versus Peer Assisted Learning: Quasi-Experimental Study to Compare Knowledge Gain of Fourth Year Medical Students in Community Health and Nutrition Course" *Res. Dev. Med. Ed.* vol. 5, no. 2, 2016.
- [4] Andrea Goncher and Joshua Devitt, "Development of global competencies through humanitarian engineering experiences" in *Proc. 28th Annual Conference of the Australasian Assoiation for Engineering Education* (Manly Beach, Australia, Dec. 10th, 2018).
- [5] Matthew Harsh, Michael J. Bernstein, Jameson Wetmore, Susan Cozzens, Thomas Woodson, and Rafael Castillo "Preparing engineers for the challenges of community engagement", *Europ. J. Eng. Ed.* vol. 42, no. 6, 2017.
- [6] Mary McCarthy, "Experiential Learning Theory: From Theory to Practice", *J. Bus. Econ. Res.*, vol. 14, no. 3, 2016.
- [7] Kevin M. Passino. "Educating the Humanitarian Engineer" *Sci. Eng. Ethics*. vol 15., no. 4. 2009.
- [8] Bryan K. Saville, Tracy E. Zinn, and Marcus P. Elliott, "Interteaching versus Traditional Methods of Instruction: A Preliminary Analysis", *Teach. Psych.* vol. 32, no. 3, 2005.
- [9] Tae S. Shin, John Ranellucci, and Cary J. Roseth, "Effects of peer and instructor rationales on online students' motivation and achievements" *Int. J. Ed. Res.*, vol. 82, 2017.
- [10] Students.ubc.ca. *Student Directed Seminars / Student Services*. [online] Available at: <https://students.ubc.ca/enrolment/courses/student-directed-seminars> [Accessed 1 May 2018].