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Work in Progress: Knowledge Translation for Biomedical Engineering Graduate Students

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I am also interested in researching: 1) the treatment of end-stage heart failure with medical devices designed to augment cardiac output, 2) the identification and diagnosis of cardiovascular disease earlier than currently possible by creating tools and methods based on blood pressure and flow waveform morphology, and 3) new and novel ways to visually display heart function by creating realistic and interactive models

Work in Progress: Knowledge Translation for Biomedical Engineering Graduate Students

Abstract

This work in progress aims to describe the development of a learning activity that required biomedical engineering graduate students, in the Institute of Biomaterial and Biomedical Engineering at the University of Toronto, to translate the knowledge they plan to gain in their own work to a broader audience. The learning activity was presented as an open-ended design project, where teams worked during a semester to translate a thesis proposal to an outreach activity suitable for an audience of high school students (i.e., grades 11 and 12). The link to an existing outreach program was chosen because it offered an authentic experience that challenged them to decide which audience to target (high school students, teachers, outreach program staff, etc.) and what their needs are. This activity was piloted in the fall of 2017 and qualitative feedback was obtained through surveys and course evaluations. In general, the feedback received was skewed towards comments that indicate this activity in its current form could be improved. These comments revolved around students feeling forced to generate ideas for a specific outreach program they were not interested in. This feedback will be used to improve the individualization of the knowledge translation activity and the plan moving forward is to measure the effectiveness of this activity by tracking how well graduate students apply the skills practiced in class to their own thesis or other activities (e.g., outreach activities) related to their research.

Introduction

Knowledge translation is defined by the Canadian Institutes of Health Research (CIHR) as: *"a dynamic and iterative process that includes synthesis, dissemination, exchange, and ethically-sound application of knowledge to improve the health of Canadians, provide more effective health services and products, and strengthen the health care system."* [1]. Knowledge translation is emphasized in health care especially because: 1) there are high costs associated with long temporal lags and 2) there are large gaps between new research and clinical practice which lead to an inefficient use of limited health care resources [2–4]. This area of scholarship has advanced to the stage where there are journals (e.g., Implementation Science) dedicated to addressing these concerns specifically. In practice, knowledge translation can be applied to the initial design of research protocols [5] and health science funding agencies are placing a greater emphasis on creating knowledge translation plans in grant applications [6–8]. One of the main reasons that researchers in biomedical engineering must begin addressing knowledge translation (at least in Canada) is that collaborative health research projects funded through the Natural Sciences and Engineering Research Council (NSERC) and CIHR that focus on interdisciplinary research between engineering and any field of health science must submit applications that have: *"… a strong focus on knowledge translation, and lead to health benefits for Canadians, more effective health services and/or economic development in health-related areas [and] all applicant teams are required to engage and collaborate with a knowledge/technology user organization that could benefit from the research results.*" [9].

There is some debate regarding the definition of "knowledge translation" [10] and how it relates to evidence-based practices [11] but in simple terms, the core questions that must be answered are: "What is known?" and "What is currently being done?" [12]. These questions lead to seeking a long term plan that guides how research can move from the "bench to bedside" [13],

which should be the objective of biomedical engineers assessing user needs when developing any medical technology [14]. The close connection that biomedical engineering has in bridging the gap between medicine and technology makes it easy to apply knowledge translation to biomedical engineering, for example: it is already guiding research in rehabilitation engineering [15–17], the development of electronic health records [18], the placement of automated external defibrillators [19,20], and supporting evidence-informed decision-making in software engineering [21].

Graduate students need to be able to communicate the implications of their work effectively and describe how their work will have meaning and impact. To these objectives, criteria (based on the principles of knowledge translation) and basic questions [22] can be posed to graduate students, for example:

- For whom is my research meaningful? How can I involve these people in my research to improve outcomes?
- How can I ensure that the right people know about my research? What is the best way of communicating my research to these different audiences?
- What would prevent my research from being translated into practice and how can I plan my research to circumvent these barriers?
- How can I evaluate if my knowledge translation efforts are effective?

These questions demonstrate that knowledge translation is inherent to every research endeavour and graduate students should be introduced to this concept early in their studies to improve their ability to communicate their motivations and implications of their work.

Approach

The Institute of Biomaterials and Biomedical Engineering (IBBME) at the University of Toronto offers a graduate course (BME1450: Bioengineering Science) that focuses primarily on enhancing communication skills (thesis, grant, and award writing, oral presentations, etc.) that will help students be successful in their research. The knowledge translation activity takes place within this mandatory course and students usually take this course in the first semester of their graduate studies. The learning outcomes for this course are framed as follows: 1) apply search techniques to inform and support research, 2) create a thesis proposal, 3) evaluate written and oral work, 4) communicate your thesis to a non-specialist audience and 5) transfer your knowledge to a broad audience. To enable these outcomes, the course was structured with a mix of individual and team work. Students worked individually to deliver a 4-page written thesis proposal and a 2-minute video based on their proposal. Both of these deliverables underwent randomized anonymous peer review (written proposal) and a face-to-face peer review (two-minute video). The teamwork component of the course required students to work in teams of 6 on a semester-long knowledge translation activity. These groups were created early in the semester by the instructor to have a variety of backgrounds (biomaterials, nanotechnology, neural, clinical engineering, etc.). After these groups were finalized, students were given 1 hour of class time per week to work with their teams. The knowledge translation activity culminated in a 3-hour symposium held on the last day of classes (of a 13-week semester) where each team had to present their work in a podium and poster format.

The knowledge translation activity was constructed to fit within the time constraints (90 hours of TA support) and scope of the course (3-hour lecture blocks for 13 weeks), be appropriate for graduate students in their first semester (thesis topic may be unclear), and provide a level of authenticity (link to a real audience). To meet these criteria and constraints, teams of graduate students were challenged to work together on a semester-long project that translated an individual thesis proposal to an existing outreach program. This program is called: "Discovery" and the connections between the graduate course and the Discovery program are shown in Figure 1. Discovery is structured to allow high school teachers (from a school that scores poorly on the Toronto District School Board's learning opportunities index) to integrate IBBME teaching lab facilities into their biology, chemistry, and physics curriculum and have their grades 11 and 12 students address biomedical engineering design challenges in this environment. Each graduate student project team was required to accomplish 4 tasks: 1) propose a theme related to biomedical engineering based on a single thesis and 2, 3, 4) propose suitable activities that could be used in the Discovery program for biology, chemistry, and physics high school students.

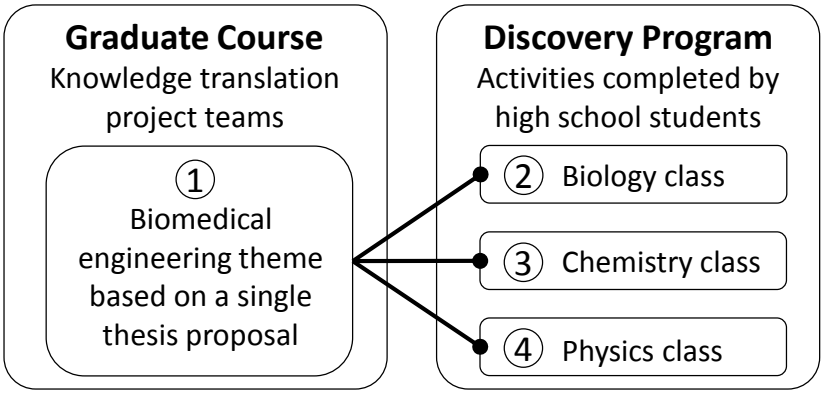

Figure 1: Main tasks that must be completed for the knowledge translation activity. Connections show the links between the tasks that each team must accomplish in the semester-long project.

To guide students in their knowledge translation project, a roadmap (see Figure 2) is presented to students. In the 2016/17 calendar year, Discovery used an overall theme of prosthetics to challenge high school students: in biology) to perform experiments to characterize a strain of bacteria found on the mating surface of prosthetics, in chemistry) to test the suitability of different variations of polydimethylsiloxane to be used as a prosthetic sock, and in physics) to create design proposals for above-knee leg prosthetics. Further information on the Discovery program and its outcomes (including how effective it was) is provided in another paper presented at the 2018 ASEE Annual Conference and Exposition entitled "IBBME Discovery: Biomedical Engineering-based Iterative Learning in a High School STEM Curriculum" [23].

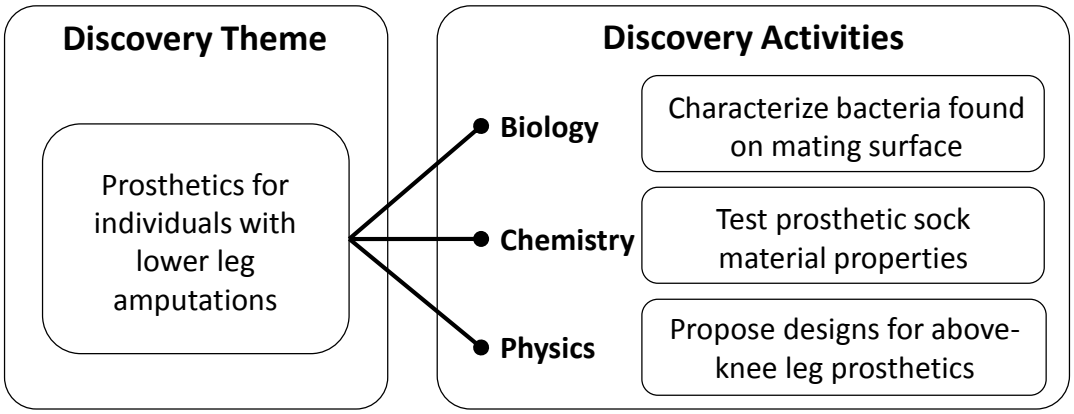

Figure 2: Example of the 2016/17 Discovery program theme and activities.
Connections show how a central theme was linked to 3 high school subjects and the activities completed by high school students in IBBME, University of Toronto teaching laboratories.

To help graduate students understand the Discovery outreach program better, the events shown in Figure 3 were created to help students understand what was expected of them and their project. The executive director of the Discovery program gave a presentation to the class that outlined the goals of the program and how it is currently implemented. Graduate students were also given the opportunity to observe the Discovery program in action to understand how it works in practice. The final symposium format was used to invite teachers and Discovery program volunteers to evaluate the ideas put forth by each team. The two-minute podium format was used to efficiently highlight the original thesis proposal and theme chosen by each team, while the poster format enabled the communication of more details regarding the individual outreach activities proposed. Each team also worked collectively to create a two-page written document that summarized their presentation and poster. To judge the effectiveness of this knowledge translation activity, qualitative feedback was gathered from standard course evaluations and extra voluntary questionnaires that asked students what they thought strengths of the course were and what area(s) they felt could be improved.

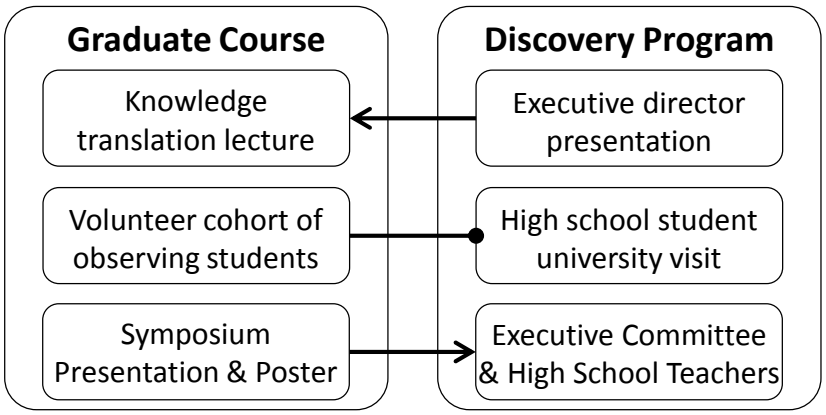

Figure 3: Interactions between the graduate course and the Discovery outreach program.
Arrows represent the direction of presentations and the connector represents the direction of observations.

Discussion

The fall 2017 semester served as a pilot run using this collaborative-based learning activity to address the learning outcomes related to communicating their proposed research to a non-specialist audience and transferring their knowledge to a broad audience. Another objective was to connect lectures on knowledge translation with an open-ended, multi-stakeholder project in an authentic way. Another rationale for linking with the Discovery program specifically, was to address the desire to add new topics for outreach activities and to encourage graduate students to become engaged with opportunities for professional development.

Regarding the project, the most common questions were related to which stakeholder/audience the team should target and what they were expected to do exactly. In general, there seemed to be some consistent confusion regarding what a team should be producing in written and oral formats. It is also important to note that some students enrolled in this course already participated as volunteers in the Discovery program, which may have provided their teams an unfair advantage stemming from a more thorough understanding of this exercise. The rationale behind allowing any individual to observe the Discovery program was an effort to compensate for this potential advantage bestowed to other individuals.

The weekly lectures occurred in a three-hour block and the middle hour was dedicated to allowing teams to work together. The rationale for allotting this time during class was that it was a common time that all students had booked in their schedule, was a common place to meet, and broke up the three-hour period into manageable blocks. The course had 85 students enrolled in the 2017 fall semester and the location was a traditional lecture theater with fixed seats. As movement was severely restricted in this environment, most teams choose to exit the class room and work in other available spaces nearby. As a consequence, guidance was not provided to all team equally. In the future, the ideal location of this course would be an active learning classroom that affords the ability for students to easily work in groups of up to 6 people.

Relevant feedback on this knowledge translation activity was collected from students (in the standard course evaluation forms) in response to the overall quality of instruction in the course. While there were only 10 comments that addressed this activity specifically, 6 were clearly negative. Students who voiced dislike of this activity noted that it felt useless, that the structure was unclear, that they were not motivated to do it, and the workload was too high. On the positive side, 2 comments indicated that it was a good idea and a strength of the course. Somewhat in the middle were comments indicated it was a distraction from their research or the idea was attractive but fell short.

Feedback received from high school teachers and Discovery program volunteers was highly positive. Teachers were very enthusiastic to get exposed to current research and were excited to translate topics to their students. The Discovery program was very pleased that they were able to connect with one team that was willing to have their ideas translated to a future theme to be presented by the Discovery program next year. Should this knowledge translation activity find a suitable format in this course, the number of students who choose to continue their ideas in

outreach programs (Discovery or other) will be tracked as a measure of how well students are able to translate their knowledge.

Future Directions

Moving forward, changes to the format of this activity will be considered to address the two main themes of feedback: 1) that the link to an specific outreach program felt forced or inflexible and 2) that the activity felt useless to some students in the context of their team or individual research. The main challenge is to balance the logistics of a large class (70 – 90 students) with individualized work that helps students prepare award applications and thesis proposals.

The limitation of this work in progress is the lack of data that demonstrates the assessment of this learning activity. The motivation behind sharing this work at this early stage is to elicit feedback from students and draft a robust plan to collect data that supports the inclusion of the knowledge translation activity/topic to graduate students being introduced to biomedical engineering. The current plan is to measure the effectiveness of the knowledge translation activity by tracking how well graduate students apply the skills practiced in class to their own thesis or other activities (potentially outreach-related) related to their research. This data would be collected by surveying graduate students who took the course and are now applying knowledge translation concepts to their own thesis proposals in advance of their first committee meeting (perhaps 6 – 8 months after completion of the course). Data will also be collected on how many graduate students decide to join existing outreach programs or create their own outreach activities based on their research.

Summary

The purpose of this work in progress is to promote discussion of a suitable way to introduce knowledge translation to biomedical engineering graduate students and allow them to apply it to their own research. Considering how to translate their knowledge to action encourages students to clarify what motivates their work, identify the barriers to their success, and communicate the implications of their research to a broad audience. Practicing and improving these communication skills will hopefully lead to a greater rate of funding or award success and greater exposure to broader applications of their research.

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