# Graduate student pedagogical impact through development and delivery of a collaborative inquiry focused high school STEM program

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## Abstract

Considering a changing academic landscape that desires skill development beyond that of traditional research, post-secondary STEM students now require broad opportunities to improve their translatable skill set. Notably, we routinely observe an increasing number of doctoral students focused on developing their teaching skills, given opportunities to pursue teaching-centred careers post-graduation; therefore, practice in innovative pedagogy is highly advantageous during graduate training. *Discovery* is a secondary school STEM education program wherein graduate students work collaboratively with secondary school educators to develop unique, inquiry focused programming that bridges the gap between secondary and post-secondary curriculum delivery and learning. Beyond meaningful impact to participating secondary students, the unique leadership, mentorship, and autonomy graduate students possess in the execution of this teaching model provides invaluable opportunity in pedagogical practice.

Depending upon the degree of involvement, graduate trainees may be involved in collaborative curriculum design, act as student group mentors, be points of contact to educators, and/or administrators to *Discovery* program operation. To date, 93 instructors have developed and delivered this unique educational program to more than 500 senior science secondary students. Quantified self-assessment reveals that the *Discovery* platform provides opportunities to improve instructor pedagogical skills while positively impacting the secondary school student STEM experience. Collaboration with experienced secondary school educators allows for instructors to combine their cutting-edge technological expertise with learned comprehension of effective teaching pedagogy appropriate for senior secondary school learning. This learning model provides opportunity for educators to share fundamental strategies in teaching with instructors that have a vested interest in developing this skill set. We observe a high level of overall personal satisfaction among trainee instructors, who further indicate a variety of goals for participation including improvement of teaching skills, knowledge translation, and development of community. Repeated instructor participation from term-to-term indicates positive self-perception of the program, in addition to direct impact on the secondary school STEM experience. The strong support and leadership of trainee instructors therefore allows *Discovery* to be a platform that blurs the divide between secondary and post-secondary learning, fostering the development of critical thinking skills crucial for the success of future STEM generations.

## Introduction

The changing landscape of academia presents challenge in ensuring graduate trainees are proficient in the development of professional skills outside of the research environment [1]. This includes capacity for knowledge translation of research outcomes to a non-expert audience, curriculum development, and effective project management [2]. Consequently, in preparing future faculty to assume academic roles and responsibilities successfully, post-secondary institutions have shifted greater focus to providing teaching development programs for trainee professional development [3]. This is particularly important given the competitive nature of securing an academic position. With increasing diversity of academic opportunities, many trainees express increased interest in pursuing non-traditional teaching-stream faculty positions, where experience in skills beyond research excellence are of increased importance.

Decisions regarding curriculum development and delivery in higher education have traditionally been autonomous, resulting from an individual faculty member's expertise, teaching approaches and beliefs, and motivations [4]. Most post-secondary instructors gain their teaching identity during the formative period of graduate training, as a consequence of teaching experiences as graduate instructors or teaching assistants, during which individuals formatively develop their beliefs and motivations about teaching [4]. This generally constitutes an 'apprenticeship model' wherein graduate trainees implement curriculum and assessments developed by previously established faculty instructors. As a result, these teaching experiences are generally the main forms of preparation received during pursuit of academic careers [5]; unfortunately, trainees generally report greater confidence about their research skills compared to their teaching and advising responsibilities as a consequence. Importantly, this model of educational mentorship has obvious limitations in pedagogical innovation, as teaching methods tend to remain constant due to the tacit nature of established instructors' teaching methods [6]. Therefore, post-secondary institutions now recognize the need for broader professional development of graduate student teaching skills. This training varies from institution to institution but is generally comprised of single-day workshops or short-term courses offered by academic units, graduate schools, and/or centres focused on teaching and learning.

While teacher training holds great value for all post-secondary academics, established or novice, graduate students tend to be the most receptive in adopting evidence-based teaching practices; this is likely because they are in the process of forming individual teaching identities, are still learning the scientific and teaching practices of their discipline, and are trained through their research pursuits to recognize the importance of evidence-based approaches [7, 8]. In addition, graduate trainees tend to be more receptive to learning skills that will make them competitive for academic positions in higher education. The ability for graduate trainees to develop self-efficacy in teaching (individual beliefs regarding influence on student learning) is critical, supporting their transition to an independent academic career [9]. Consequently, the outcomes of relevant professional development programs for graduate students have great potential to influence next generation teaching approaches, and subsequent innovation in undergraduate education [10].

Interestingly, and of relevance to our current model, self-efficacy varies for graduate students in different disciplines. It has been determined that a STEM (Science, Technology, Engineering, Math) environment is a negative predictor of self-efficacy; STEM graduate student instructors feel less able to foster a positive learning environment than instructors in the humanities [4]. However, while this may be the case in the classroom setting, active learning and effective dissemination are known to be important modes of pedagogy in STEM fields [11]. This is reflected in the positive influence of graduate instructor disciplinary association in STEM on student engagement, supporting development of instructor self-efficacy [4].

Despite holding expertise in their respective fields, academics often find that if they have not studied teaching and learning, they are challenged to effectively convey material of their own interest [12]. Even intelligent individuals with great enthusiasm cannot easily succeed in teaching without appropriate training and preparation, and therefore teachers with knowledge of teaching and learning are more effective with students, particularly given tasks requiring problem solving. As such, despite perceptions that training programs preparing educators for secondary school education are lengthy, and develop different skills than what is required to teach at the post-secondary level, substantial evidence indicates that in general, teachers with greater preparation for teaching are more confident and successful than those with little or no specific training.

In an effort to foster curriculum development and teaching skills, graduate students at University of Toronto created *Discovery*, an inquiry-focused iterative learning experience for local secondary school STEM students [13, 14]. This program provides a platform to bridge the perceived university/secondary school teaching divide, and generate productive dialogue, collaboration, and learning among teaching instructors in both settings. STEM classes, particularly at the secondary and early undergraduate levels, often consist of theoretical discussion and/or laboratory assignments with prescribed step-by-step instructional approaches that limit student autonomy [4]. In an effort to address evolving pedagogy, *Discovery* allows graduate student instructors to create engaging learning experiences for senior secondary school students that encourage critical thinking and problem solving, meanwhile supporting development of teaching self-efficacy. Secondary school students visit university facilities in their class cohorts, accompanied by their teachers, to execute project-based learning. A selected overarching global research topic is sub-divided into subject-specific research questions (i.e., Biology, Chemistry, and Physics) that students work in small groups to address, iteratively on-campus and in-class, during a term-long project (**Figure 1A**). The *Discovery* framework provides secondary school students the experience of an engineering capstone design project (including a motivating scientific problem, a discipline-specific research question, and systematic determination of a professional recommendation addressing the needs of the problem posed) meanwhile providing graduate student instructors the opportunity to develop self-efficacy in pedagogical and teaching skills under productive collaboration with innovative secondary school educators. *Discovery* provides multi-level opportunities for engagement in teaching and learning. In the context of the current paper, we describe the structure of the *Discovery* program as it pertains to volunteer instructor engagement, and provide data regarding graduate trainee professional development in teaching. To give insight into motivation and outcomes of the involved trainee population after six terms of *Discovery* offerings, we characterize trainee involvement longitudinally and by degree program, and provide insight into self-assessed professional and pedagogical development from survey response data.

## Framework of programming delivery

In the context of biomedical engineering (BME), *Discovery* programming is developed each term as a collaboration between secondary school educators and graduate student instructors with a central encompassing theme of study (**Figure 1A**). *Discovery* follows the same structure each term, with novel programming to frame a new cutting-edge element of BME within the context of relevant upper year secondary school STEM curriculum (**Figure 1B**). This falls both in the context of relevant classroom content, but also highlights required outcomes in the required Ontario secondary school science curriculum; “Scientific Investigation Skills and Career

Exploration" [15]. Throughout the term, secondary school educators work with graduate instructors to ensure participating students understand fundamental and relevant scientific theory; secondary school educators are solely responsible for student assessment.

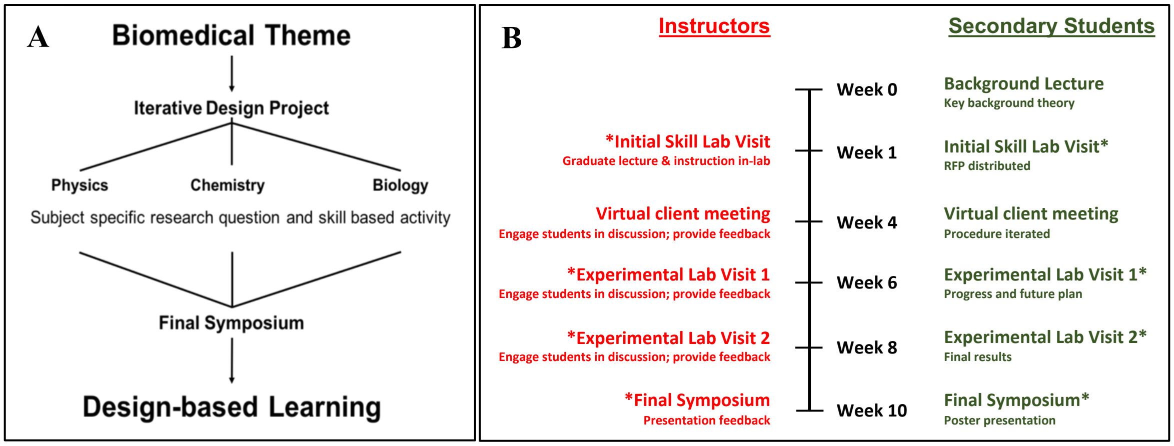


**Figure 1: Organizational structure of *Discovery* programming.** (A) Overall term structure of Discovery (B) Breakdown of student and instructor commitments and interactions, asterisk (*) indicates on campus activity, while the remainder of work takes place in class and may be supported with virtual communication.

Collaboration between secondary school educators and graduate student instructors serves as the foundation to the multi-tiered beneficial outcomes of the *Discovery* model. Herein, each party contributes their specific experience from the beginning, allowing for combination of cutting-edge innovations in the BME learning sphere (graduate students) with relevant curriculum contexts and appropriate pedagogy (secondary school educators). Given this synergy, an overall theme and subject-specific research questions are selected each term, giving consideration to: (a) an innovative area of BME that is relatable to students; (b) a match to appropriate subject-specific curriculum content; and (c) opportunities to harness research methods and equipment that are unique to university facilities (i.e., not available in the classroom). Iteration with these strategies allows for optimization of program topics capitalizing on respective expertise. Importantly, corresponding deliverables from the *Discovery* model are graded only by secondary school educators and constitute 10-15% of final course grades. Upper level science courses tend to encompass a "summative assessment" (i.e., course project) and therefore these deliverables collectively align with this mandate. This rationalizes secondary school educator participation as excess time commitments are minimized given the substitution from delivery of a similar task in the classroom. Further, the administrations of participating schools have been ardent that their teachers participate, beyond the articulated benefits to student learning, given the inherent opportunity for teachers to broaden their professional perspectives on the cutting-edge of STEM innovation.

Each semester, the selected research theme is divided into discipline-specific concepts of programming, ensuring relevance to multiple STEM subject areas meanwhile highlighting the diversity of BME (**Figure 1A**). To introduce the relevance of each chosen concept in class, secondary school educators lead their own cohort of students in completion of background research essays (sample term of programming shown in **Table 1**). Although involved throughout ideation, the first interaction between graduate instructors and students occurs during the first on-campus visit to university teaching laboratory facilities (**Figure 1B**). At this time, students engage in a skill-building protocol which provides an opportunity to understand analysis techniques and equipment relevant for their independent group projects. At completion of this session, student groups are presented with a course discipline-specific research question in the form of a 'Request for Proposal' (RFP) by their graduate student instructors. Students are also presented with the inventory of relevant lab equipment and reagents available for their use. Armed with this information, students work independently (i.e., during work periods in class or as homework) to develop a group-specific experimental plan. Secondary school educators and graduate instructors provide feedback to these proposals; educators through evaluation of the written proposal, and graduate student instructors during an electronic video meeting where student groups must pitch their protocol. This feedback allows students the opportunity to revise their plans in class prior to on-campus experimental execution.

**Table 1: Sample *Discovery* curriculum encompassing a central BME theme and discipline-specific research questions**

| | **Discipline Topics** | | |
|---|---|---|---|
| **Theme** | **Biology** | **Chemistry** | **Physics** |
| Biomedical engineering technologies in assessment and treatment of chronic conditions | Validating an assay for T-cell migration with different drugs | Optimization of extended drug release hydrogel formulation using alginate capsules and colored dye | Design of a low-cost anemometer for assessment of breathing rate in asthma patients |

Once on campus at the relevant laboratory for their research study, students immerse and execute their independent experimental plans for data collection. Data analysis and assessment are consequently performed in class or as homework and in trial-by-error fashion, yielding opportunity to learn from shortcomings. Students are guided by instructors in optimizing their protocols before returning to the university for a second opportunity to collect final data. Independent time is used to assess all process and data, and each student group creates a scientific poster based on their study outcomes. All students are required to present their findings at the on-campus research symposium, allowing verbal defence of their selected methods and process, analyses, interpretations, and design recommendations to a diverse audience that includes peers, STEM educators, undergraduate and graduate students, and faculty.

**Graduate student instructional roles**

Given the size of *Discovery* student cohorts, graduate instructors fulfill a number of different roles within the organizational structure (**Figure 2**). The majority of graduate volunteers act as instructors that interface directly with secondary student participants. This requires the lowest commitment of time (~ 20 hours per term), with the majority devoted to contact time during on-campus activities. These instructors engage with the discipline (i.e., biology, chemistry, or physics) best aligned with their BME expertise, interests, and previous program engagement. The number of instructors assigned per subject discipline is directly dependent on the size of each class, with working groups consisting of 3-4 students. Each graduate instructor works with 2-3 student groups from one school, and oversees application of relevant theory, development of student assessment protocols, and generation of final recommendations to the original motivation outlined in the discipline-specific RFP. Instructors also spend required time in advance of the semester to engage with Stream Leads (**Figure 2**) to ensure competence in delivery of content to secondary students as well as appropriate competence in relevant laboratory, design, and interpretive skills.

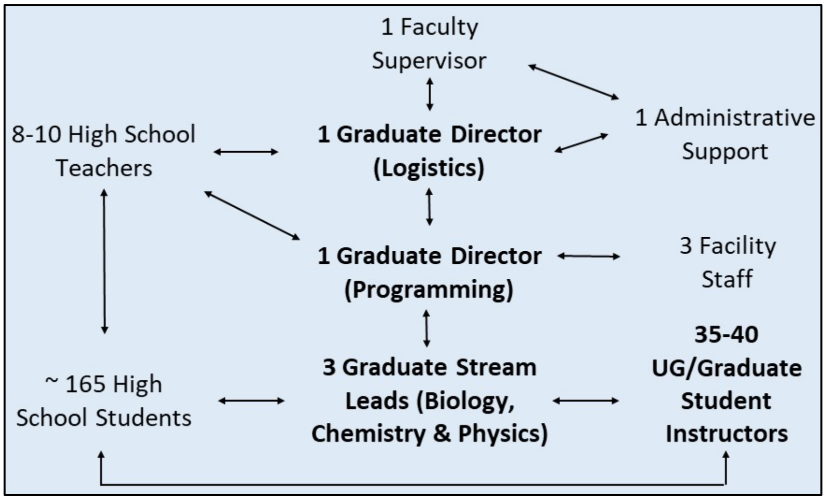


**Figure 2:** ***Discovery*** **trainee leadership structure each semester**

A smaller group of graduate students (3 per school/semester) commit a greater amount of time (~ 2-fold more; 40 hr/semester) by fulfilling the role of Stream Leads. A Stream Lead is an individual instructor that oversees specific curriculum development for their assigned STEM discipline. These graduate instructors are matched based on their area of interest, thesis expertise, and prior knowledge of instrument use and protocol development. In conjunction with the Programming Director, the Stream Leads develop the discipline-specific RFPs (research questions) and associated content (**Figure 3**). The Stream Leads create and test relevant theory and skill development protocols, provide pre-programming training to instructors and secondary school educators, generate discipline-specific background lecture content, and oversee all on-campus activity. In addition, the Leads retain responsibility for strong communication with all other graduate instructors, teaching facility coordinators, and the Programming Director.

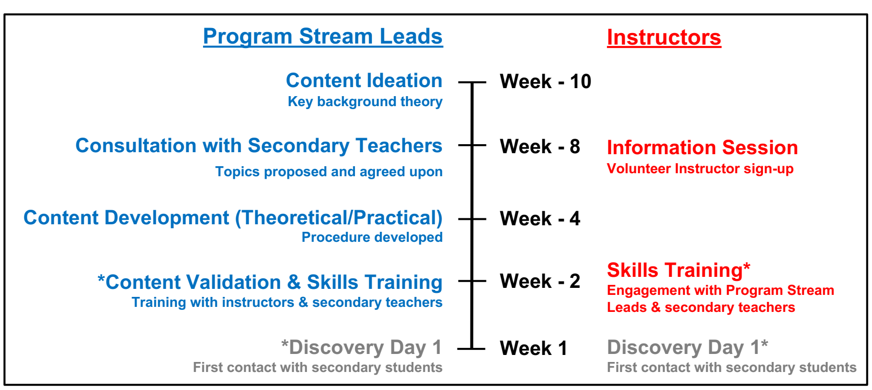


**Figure 3: Involvement of trainees in programming ideation**

At the highest level of administration, two graduate trainee Program Directors oversee all components of *Discovery*. To date, these have been doctoral candidates with a vested interest in development of teaching skills, knowledge translation for improving the STEM experience of secondary students and improving the perception of STEM by the general public. The current Director (Logistics) co-founded *Discovery* and remains responsible for strong communication with secondary school educators and administration, the Director of Programming, and the Stream Leads. This Director also oversees weekly meetings with the Faculty Advisor and is responsible for recruiting volunteer instructors to meet the curriculum and instructional requirements each semester. The Director (Logistics) works closely with the Director (Programming) in advance of each session to collaborate with secondary school educators in discerning a relevant global research theme of interest. The Director (Programming) subsequently works closely with the identified Stream Leads to generate discipline-specific research questions in the form of RFPs. The Director (Programming) further invests time with each Stream Lead to create relevant skill development protocols and associated STEM theory for laboratory and classroom discussion. During each on-campus session, the Directors monitor all activity and are available to assist at all levels of activity.

**Instructor training**

All *Discovery* instructors, once recruited and familiar with program expectations, are required to sign a written agreement signifying their commitment to delivering a high-level educational experience. Consequently, each instructor must complete mandatory Workplace Orientation & Safety training and pass the relevant safety test at the onset of program engagement in order to instruct in laboratory spaces. These training sessions are provided by the coordinators of the relevant teaching facilities/laboratories in which the secondary school students will be working. All participating secondary students must also undergo safety training before obtaining permission to work in these campus spaces.

Instructors must also attend a workshop on teaching delivered by the Faculty Advisor (a Teaching Stream faculty member) at the beginning of the semester. This training session provides practical information on teaching and has been co-developed with secondary school teachers based on their extensive training and experience in fundamental teaching methods. In addition, instructors receive hands-on training and guidance from Stream Leads and the Director (Programming) regarding the specific activities outlined for the programming of their discipline – this includes relevant theory and a Skills Training session (**Figure 3**). Graduate instructors are expected to review and be familiar with this content, ensuring adequate teaching and supervision of secondary school student participants. It is important to note that at no time do graduate instructors assess student deliverables – these tasks remain the responsibility of the classroom educators.

**Outcomes of instructor engagement**

*Discovery* has completed six terms of program delivery, with total secondary school student participation now exceeding 500. Our previous analysis focused on beneficial outcomes to secondary student participants [13, 14]. Concurrently, we now share the multi-factorial opportunities to teaching skill development through this model. Both qualitative and quantitative outcomes suggest *Discovery* is having significant impact both on graduate (and undergraduate) student instructor development of professional skills, as well as secondary school student engagement in STEM.

**Instructor participation**

During the first 6 semesters of programming (2017-2019; Spring & Fall each year), 93 university student trainees engaged as program instructors, with 24 trainees acting specifically as Stream Leads (**Table 2**; 50.5% female; 49.5% male). These students are pursuing a range of degrees, including an increasing number of BME undergraduate students, given recent increases in program size and mentorship strategies. While the engagement of doctoral trainees is not surprising given focus on professional skill development for future academic pursuits, we are consistently surprised by the number of Master's trainees involved in the program. In the context of skill development, Master's students may consider teaching and mentorship development in a more tangential manner, such that experience with educational strategies will translate to work in non-academic settings. It is further likely that this trend reflects student engagement at the onset of degree programs, before the development of significant research pressures.

**Table 2: Distribution of degrees pursued by instructors during program participation**

| Degree | BSc | MASc | MEng | MHSc | PhD | PDF | Total |
|---|---|---|---|---|---|---|---|
| Total # of instructors (% total population) | 17 (18.3%) | 36 (38.7%) | 4 (4.3%) | 10 (10.8%) | 23 (24.7%) | 3 (3.2%) | 93 |
| Total # of stream lead instructors (% total lead population) | 0 (0%) | 11 (45.8%) | 0 (0%) | 2 (8.3%) | 9 (37.5%) | 2 (8.3%) | 24 |

Of particular interest to this study is how participation in *Discovery* supports graduate trainee professional development, particularly given the changing landscape of academia and career opportunities for this population of trainees. The value that trainees place on program involvement can perhaps be best indicated by volunteer retention over time (**Table 3**).

**Table 3: Instructors participating in multiple terms of programming**

| # of participating terms | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| # of instructors | 54 | 18 | 10 | 7 | 1 | 3 |

To date, 41.9% of instructors (39/93) have participated during more than one programming semester; value is further highlighted with exclusion of new instructors joining the program for the first time in Fall 2019 (the last semester of programming included in this analysis) which reveals that 72% of instructors through Spring 2019 participated at least twice in the first 5 semesters of programming. A similar trend is observed for Stream Lead instructor participation, as 75% (18/24) students in this population have engaged more than once in program delivery. These data support the concept that the number of semesters an individual has participated in graduate school is a positive predictor of self-efficacy [4]. Longitudinal involvement in this programming approach could provide multi-faceted benefit to graduate students, including the opportunity to continuously improve pedagogical approaches through multiple programming iterations. Interestingly, the level of graduate student instructor teaching experience, pedagogical training, and duration of graduate training have previously been shown to not be significant predicators of classroom engagement [4], suggesting that the contributions of *Discovery's* undergraduate and Master's level instructors may be just as impactful as the contributions of doctoral instructors. Importantly, it is worth reemphasizing the entirety of *Discovery* participation is on a volunteer basis, making the continued involvement remarkable considering the increasing time constraints that evolve with progression of a graduate degree.

There are multiple reasons provided by instructors who choose to discontinue participation in *Discovery*. These include graduation, personal time constraints, perception that personal goals are not being met, or lack of support from thesis advisor. The latter is unfortunate as we believe this program provides a legitimate platform for development of teaching skills, and the feel that the extracurricular time commitment is not excessive and should not impede research successes. In fact, involved trainees have often remarked on the value of involvement in teaching experiences in helping them to mentally reframe their research pursuits, in addition to the valuable soft skill development that is becoming ever more valuable. As an indicator of involvement, graduate instructors are eligible to receive validation of participation on their transcript given that *Discovery* is a partner of the University of Toronto School of Graduate Studies Graduate Professional Skills Program. Likewise, undergraduate instructors are eligible to receive notification of participation on their transcript through the University of Toronto Co-Curricular Record. No evidence of increased time to degree completion has been shown by Prevost et al, demonstrating graduate student engagement in a teaching development program (such as *Discovery*) to be of overall benefit [10].

**Graduate participation objectives and skill development**

Overall instructor perception data collected using an anonymous survey instrument suggests that graduate students find sufficient value in the *Discovery* model to engage with the program. To measure objectives for involvement, achievement of goals, and relevance to skill development, instructors were surveyed at the end of each term of participation. Survey responses were voluntary and therefore do not track the entire instructor cohort identified above. Of 57 survey respondents, a majority (86%) indicated that they would participate again, with 96.5% of instructors indicating that they believed their personal goals had been achieved by participating (**Table 4**). Interestingly, students engaging as Stream Lead instructors placed greater value on development of effective teaching (64.7% versus 54.4% of global instructor population) and opportunity for practice in curriculum development (41.2% versus 24.6% of global instructor population), suggesting perception of *Discovery* as a platform for professional development in teaching is emphasized in those taking a greater responsibility in programming ideation.

**Table 4: Personal goals of *Discovery* instructor participation. N=57**

| Goals of Participation | % Total Instructor Population | % of Stream Lead Instructor Population |
|---|---|---|
| Knowledge translation | 82.5 | 76.5 |
| Development of effective teaching | 54.4 | 64.7 |
| Give back to the biomedical (institution) community | 50.9 | 47.1 |
| Opportunity to try new teaching methods | 49.1 | 52.9 |
| General practice of teaching | 42.1 | 41.2 |
| Work with graduate trainees from a different field of BME | 26.3 | 35.3 |
| Enhance curriculum development skills | 24.6 | 41.2 |

Data further suggest that the majority of participating instructors, Lead or otherwise, view the *Discovery* platform as a mechanism to practice knowledge translation (82.5% and 76.5%, *respectively*). In addition, although no differences were observed between instructors in general and those that acted as Leads, at least half of the trainees felt that this model provides opportunities for testing new methods of teaching (49.1% versus 52.9%), but were less inclined to view engagement for the general practice of teaching (42.1% versus 41.2%). Although not specifically determined due to the anonymous nature of survey data collection, it is hypothesized that many of the undergraduate and/or Master's level participants, or those early in their degree program, view *Discovery* as a mechanism to engage with others as they expand their scientific network.

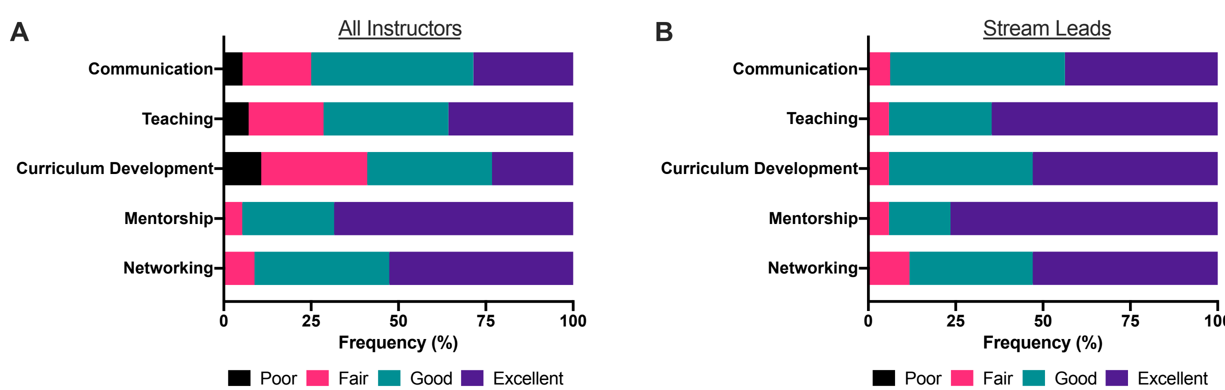


**Figure 4: Instructor Perception of Skill Development** Frequency distribution of survey responses for (A) All Instructors and (B) Stream Leads (n=57).

When asked to consider the impact *Discovery* had on professional skill development, the majority of instructors perceived positive outcomes (**Figure 4**). Particular emphasis was placed on the value of mentorship and networking (**Figure 4A**). These outcomes were further highlighted in the Stream Leads population, indicating the increased perceived value of additional responsibilities (**Figure 4B**). This presents the value of experiential interactions with students for graduate instructors; networking and mentorship are skills that are translatable across a variety of career pursuits. Given the context of the *Discovery* program structure, this is not surprising but also not necessarily reflected in the motivation for involvement. In fact, one could suggest that this is an indicator of the importance of such training programs for graduate skill development. The overwhelmingly positive perceived improvement in mentorship and networking necessitates a need or opportunity for improvement as a baseline. Continued program development will examine skills perceived as fair-poor, with the intention of expanding opportunities for engagement and teaching practice.

**Instructional impact on secondary school student learning outcomes**

The effectiveness of instruction by graduate trainees can be further validated by the downstream impact on secondary school student learning in the *Discovery* model compared to normal in-classroom instruction and outcomes. We have identified a sub-population of secondary school students that thrive in the immersive, problem-solving STEM environment provided by the *Discovery* instructors: these students exhibit improved attendance during the program compared to regular school attendance, and also present improved scores in program deliverables compared to regular class assignments [14]. Notably, a cohort of students who appear to struggle in the knowledge-focused classroom environment excelled during *Discovery*, displaying average grades >18% higher for collated program assignments compared to their term course average. There is an advantage of peer learning and accommodation of varied learning styles within the varied practical environments on campus, in addition to comfort in learning provided by having students engage within their regular class cohort and with their classroom educator. Interestingly, students tended to work in groups with similarly performing peers. In addition, repeated secondary student involvement, by virtue of being enrolled in a different science class in another semester, supported academic achievement as a consequence of improved student comprehension of project execution with recurring exposure to the project-based learning environment. We are now examining the difference in program impact between cohorts of students from two different secondary schools, including the school where impact was first identified, to assess how external challenges influence student *Discovery* outcomes. These findings are available in proceedings *Discovery: Differential student impact is evident within an inquiry-focused secondary/post-secondary collaborative STEM program (Evaluation*), being presented concurrently in the *Pre-College* division of *ASEE 2020*. Although there are a number of factors that impact student academic performance, our current observations suggest that *Discovery* instructors are responsible for creating positive and stimulating STEM learning environments and curriculum.

**Dissemination**

Program Directors have taken advantage of the opportunity to collect anonymous stakeholder feedback (i.e., survey data) and grade data (i.e., deliverable scores and attendance) for the purpose of studying the impact of this teaching and learning model. Working with the Faculty Advisor, ethics approvals have been obtained from both the University of Toronto Health Sciences Research Ethics Board (Protocol # 34825) and the Toronto District School Board External Research Review Committee (Protocol # 2017-2018-20). To date, data has been analyzed for dissemination of findings to relevant communities of practice, including the American Society for Engineering Education (2018), the Biomedical Engineering Society (Education section; 2017-2019), and the Canadian Engineering Education Association (2017). In addition, a manuscript on secondary student learning outcomes has been archived online and submitted for consideration at a relevant educational journal. The opportunity for graduate trainees to garner feedback and contribute to pedagogical research and learning is inherently relevant to academic skill development.

**Conclusions and future considerations**

It is our belief that *Discovery* programming provides a framework for delivery of inquiry-focused learning that bridges the gap between secondary and post-secondary teaching and learning, with lessons in teaching and curriculum delivery being shared between secondary school educators and graduate trainee instructors, and in particular, those trainees electing to engage as Stream Leads. The success of *Discovery* is built on collaboration, therefore continuing to foster this dynamic is an important part of our mandate. This is critical as every secondary school educator brings their own teaching philosophies and methods that can be shared with our graduate instructors as they work to develop their individual pedagogical skills and teaching self-efficacy. The Canadian federal government has found sufficient value in the program and its stakeholders to award *Discovery* with a National Sciences and Engineering Research Council (NSERC) PromoScience grant. This financial support brings opportunities for program expansion by including STEM classes from new secondary schools. Moving forward, program sustainability will result from integration with an on-campus centre focused on engineering education, wherein we envision *Discovery* could serve as a for-credit opportunity for graduate student teaching skill development and ongoing educational research platform. Program Directors are now recruiting participants from a wider volunteer population (i.e., undergraduate students; students from other STEM departments) and are organizing transition in the leadership team as another group of dedicated instructors prepares to graduate.

The *Discovery* program is still in its relative infancy as a model of education, and it is with excitement we eye the potential long-term outcomes. It is our goal to track the success of participating secondary school students and instructors as they develop into future leaders in STEM. Through longitudinal assessment, coinciding with program optimization and expansion, we will be able to truly understand the potential of this learning model in pedagogical change, particularly in terms of post-secondary trainee professional development. We recommend that this teaching and learning model be formalized as a course in curriculum development and implementation during graduate studies. Therein, given the outlined discussion around translatability of secondary student mentorship to post-secondary pedagogy, graduate trainees will be given greater autonomy to iterate on their teaching skills in a controlled environment. Outcomes to date identify that institutional graduate training programs should be aware of, and continue development of, the resources available for training graduate students in teaching.

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