

# TECHNOLOGY ENTREPRENEURSHIP @ SFU: EXPERIENTIAL, INTERDISCIPLINARY LEARNING THROUGH AN IMMERSIVE TWO-YEAR PROGRAM

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**Abstract** – This paper provides an overview of experiences to date in developing and delivering the Technology Entrepreneurship @ SFU program - an interdisciplinary program in which Mechatronic Systems Engineering and Business students at Simon Fraser University collaborate on market-driven, entrepreneurial initiatives that simultaneously satisfy their respective capstone project requirements. The paper includes a discussion of program scope and objectives, design, implementation and revisions. The role of the program in providing experiential, interdisciplinary learning for Engineering and Business students through an immersive experience is discussed. Qualitative and quantitative program results to date are reviewed, with program enrollment and completion trends, course evaluation data and key stakeholder metrics indicating a level of success in: (1) creating an interdisciplinary, entrepreneurial culture amongst the students, (2) preparing students for future career paths that may include entrepreneurship and (3) potential further commercialization of prototypes developed in the Technology Entrepreneurship program. Longer-term measures of success are also considered and discussed in light of the experiences to date.

**Keywords:** Interdisciplinary Capstone Project, Product Development, Entrepreneurship, Experiential Learning

## 1. INTRODUCTION

In recent years there has been a notable trend towards interdisciplinary, experiential learning initiatives in higher education as an approach to prepare students for the type of work and collaboration that is needed to solve problems faced in the current workplace and by society more generally [6]. Within engineering programs, a natural place for this to occur is within the context of the typical senior year “capstone” design project. The literature includes several examples of programs in which capstone teams are formed across the boundaries of different Engineering disciplines [2], [3], [4], as well as those in which teams form more broadly across Faculties [1], [5], [6], [7], [8], [11]. In specific cases, programs are aimed at stimulating interactions between Engineering (and/or Science) and Business students, with a focus on

entrepreneurship, e.g. [5], [7]. Significant work has additionally been done to quantify and characterize the advantages associated with interdisciplinary capstone programs in preparing students to solve real-world problems in effective ways [3], [6], [9], [10]. Reported benefits include demonstrably improved outcomes in e.g. design quality and subsequent job placement rates, while reported challenges include differences in expectations amongst students based on different curricula in their respective major programs, imbalance of contributions and lack of effective communication.

Launched in 2012, the Technology Entrepreneurship @ SFU (Tech-e@sfu) program is executed as a collaborative endeavor between the School of Mechatronic Systems Engineering (MSE) and the Beedie School of Business at Simon Fraser University, with two co-directors (one from each School) developing and overseeing the program. Funded collectively by the Spencer Creo Foundation, British Columbia Innovation Council (BCIC) and Simon Fraser University, Tech-e@sfu engages (nominally) third- and fourth-year MSE and Business students in a two-year program aimed first at building an entrepreneurially oriented community and subsequently at forming interdisciplinary teams for the pursuit of market-driven capstone projects. The authors of this paper assumed the co-director roles for the program in 2013.

## 2. PROGRAM DESIGN AND DEVELOPMENT

### 2.1. Program Scope Objectives

In establishing the Technology Entrepreneurship @ SFU (Tech-e@sfu) program, the key stakeholders (including the funding partners and SFU) developed the following scope and objectives for the program:

- A focus on building the entrepreneurship skills and knowledge of teams of talented Business and Engineering students.
- A practical (rather than academic) focus, with successful students mentored and introduced to the local network of business leaders and investors.
- Multi-year programming that is integrated with the students’ Business or Engineering course

requirements, taking students through the stages of innovation from idea to “market readiness / business launch” by the time of their graduation.

- Active involvement of industry partners, established entrepreneurs, SFU Venture Connection (a university-wide program offering entrepreneurship training services, mentoring and opportunities for students and recent alumni) and experienced Business / Engineering students.
- A market-focused approach with the objective of producing graduates who will have the highest potential to create innovation and wealth, and to contribute to local economic growth.

## 2.2. Pilot Program Implementation

As noted in the preceding section, the intent in developing the Tech-e@sfu program was to implement a multi-year program, integrated with the existing Business and MSE program requirements. Given the demanding and relatively rigid MSE program specifically, the Tech-e@sfu program required a design that introduced a minimum additional set of formal course requirements.

In order to gain some initial experience and to allow students to benefit quickly from the new opportunity, a pilot version of the program was launched in January 2012. This version spanned the Spring and Summer terms of a single (academic) year, assembling final-year MSE and Business students (through networking / team-building sessions) into combined teams for the purpose of pursuing an entrepreneurial initiative in conjunction with their corresponding and respective capstone programs. Active professional mentorship was provided to the teams, as well as support to attend a series of entrepreneurial workshops. Students received a financial award to assist in the development of their initiatives, and further were provided access to a pool of prototyping funds (to reimburse hardware costs associated with product development).

The pilot program ran for two academic years (2011/2012 and 2012/2013), with teams pursuing projects in the medical, navigation, communications, agricultural and retail sectors. A cohort of 19 students participated in the 2011/2012 offering (forming three teams), and a cohort of 11 students participated in the 2012/2013 offering (forming two teams). In each case, teams were successful in developing business plans and prototype systems, and in satisfying the requirements of the corresponding capstone programs.

## 2.3. Pilot Program Evaluation

While student teams in the pilot program were successful in developing prototype systems and business plans, none of the teams chose to pursue their initiatives further. Additionally, some concerns were raised

regarding the enrollment trend and student satisfaction levels (based on direct input from participants and also survey responses provided to external funding partners).

Focus group sessions were held with participants from the pilot program in order to gain feedback for use in a revision and re-launch. In describing their experiences, students raised the following major (summarized) points:

- The spirit of the program was highly positive, and provided a good opportunity to “work together”.
- The mentorship provided, and particularly the workshops attended, were very useful.
- Projects were successfully completed, and the lab space provided (at SFU) was well used.
- Student teams needed to form sooner, with sufficient time for team building and project development (to ensure alignment amongst the team).
- There was a need to improve communication about the program and clarify its structure, requirements, incentives and funding mechanisms.
- There was a desire for more mentorship, and earlier in the program
- In some cases, there was a desire for more flexibility in the MSE capstone program, as students felt constrained to follow their initial project proposals versus “pivoting” as needed based on an evolving understanding of the target market.

## 2.4. Program Revision and Re-Launch

On the basis of the pilot program evaluation, several modifications were made to the program design in anticipation of a “production” re-launch in the 2013/2014 academic year. In summary, the format and attributes of the program as re-launched are:

1. The program spans two (academic) years, with students applying for admission during the Fall term of their (nominal) third year of studies.
2. In the first academic year of the program (Spring and Summer terms), students engage as a multi-disciplinary community but do not yet form project teams.
3. A series of networking / team-building events and informational workshops are held during the first academic year of the program, in order to develop a common language and sense of trust amongst the students.
4. Additionally, students take “crossover” courses to underpin a common language and establish additional empathy. Business students take MSE 111 (Mechatronics for Non-Engineers), while Engineering students take BUS 238 (Introduction to Entrepreneurship and Innovation).
5. The students coalesce during the subsequent Fall term into (self-selected) interdisciplinary teams based on mutual business / technical interests and established working compatibility. Project teams

develop proposals, which form the basis for their submissions and project work in their respective capstone programs as well as Tech-e@sfu. Based on the technical and market aspects of the project proposals, industry and alumni mentors are identified and placed in contact with each team.

6. Team-based capstone project work takes place in the following Spring and Summer terms, with Engineering and Business students registering in their respective capstone courses. Fundamentally, Business students are expected to develop a strong market understanding, prototype, business plan and pitch through their capstone program, while Engineering students are expected to complete a significant product design and prototype.
7. Students in the Tech-e@sfu program are additionally required to register for two single-credit courses (one in each of the Spring and Summer terms), which run alongside the established capstone programs. The courses are co-listed as MSE 403 / BUS 404 (Technology Entrepreneurship I) and MSE 404 / BUS 405 (Technology Entrepreneurship II). Through these courses, students convene once per week in a common class led by the Business and MSE co-directors. During these classes, students receive some structured content (e.g. project planning, team dynamics, and intellectual property management), but the sessions are largely oriented towards guidance, mentorship, coordinated project work and presentations. Deliverables include a coordinated project plan, presentations, event participation, and individual reflections.
8. To further encourage collaboration and demonstrate dependency on each other's skillsets, mid-way through the Spring capstone term, students present ("pitch") their projects (technical and market aspects) to an industry panel, competing for their share of an overall pool of prototyping funds. The panel collectively determines (based on each presentation) what level of funding will be awarded to each team.
9. In addition to a team prototyping budget, each student receives an individual award (Ken Spencer Award in Technology Entrepreneurship), intended to support more general business development expenses. Teams must decide amongst themselves how to allocate and manage these funds.
10. At the end of the Summer term (i.e. at the completion of the capstone programs), student teams make a final presentation to an industry panel, demonstrating the progress made with the funding that was allocated. At this point the industry panel can make recommendations regarding next steps in commercialization.
11. Teams that wish to pursue their projects further are assisted in moving toward an appropriate incubation such as (e.g.) SFU Venture Connection.

### 3. PROGRAM METRICS AND RESULTS

#### 3.1 Program Enrolment Levels

Enrollment and completion levels for the Tech-e@sfu program are shown in Figure 1. As shown and as previously mentioned, 19 students enrolled in the 2011/2012 (pilot) cohort and completed the program, while 11 students enrolled in the 2012/2013 (pilot) cohort and completed the program. In 2013/2014, the two-year (revised) program was launched. In 2013/2014, 36 students enrolled in the program with 23 of these students (organized into five teams) subsequently completing in 2014/2015. In 2014/2015, 40 students enrolled with 24 of these students (organized into four teams) expected to complete in 2015/2016. As of April, 2016 a total of 32 students have enrolled in the 2015/2016-2016/2017 cohort.

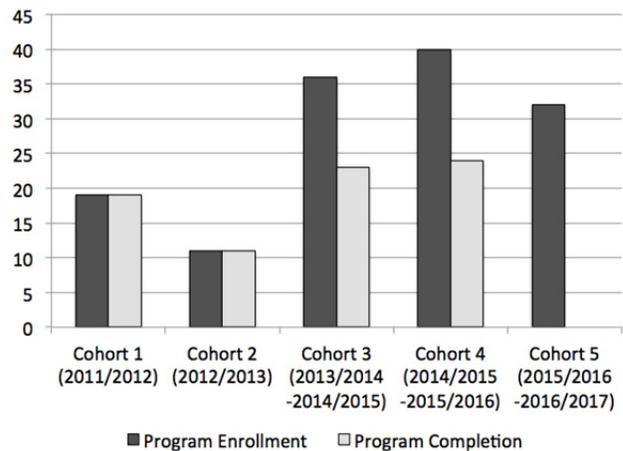


Figure 1. Enrollment and completion levels during the pilot (2011/2012 and 2012/2013) and revised (2013 onward) phases of the Tech-e@sfu program.

The enrollment data suggests that (a) the revised program has stimulated an increased interest, by addressing some of the limitations of the pilot offering. With that said, there is a significant level of attrition that occurs during the first few months of the program as students determine whether the entrepreneurial environment and interdisciplinary community is a good fit with their academic and career ambitions. Also in some cases students withdraw due to extended co-op placements (normally with the intent to re-apply for the subsequent cohort). A typical cohort size of 24 students appears to represent the typical and realistic demand for the program currently.

Figure 2 shows the distribution of applicants (based on major program) for the 2013/2014, 2014/2015 and 2015/2016 cohorts. The "Other" category represents students that are registered in the Beedie School of Business' Certificate Program in Entrepreneurship and

Innovation, although their major program is in a different Faculty. Considering these effectively to be Business students in the program, the ratio of MSE/BUS student applicants has been 57/43%, 68/32% and 57/43%, respectively.

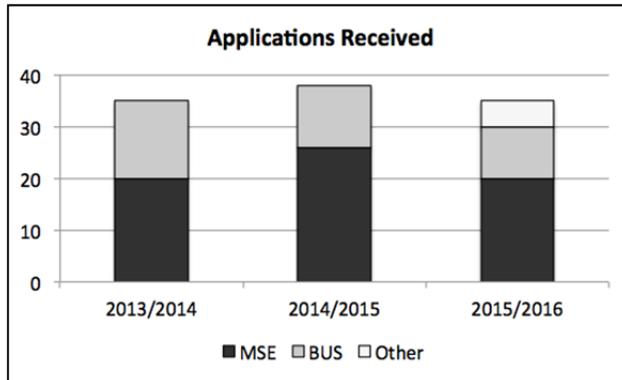


Figure 2. Distribution of Tech-e@sfu applicants between Engineering (MSE), Business (BUS) and Other majors.

### 3.2 Quantitative Course Evaluations

As an indication of student experience in the production version of the Tech-e@sfu program, Tables 1 and 2 provide quantitative results from course evaluations corresponding to MSE 403 / BUS 404 (Spring 2015) and MSE 404 / BUS 405 (Summer 2015), as attended by the 2014/2015 cohort. The questions included are limited to those associated with the course (and not the instructors).

**Table 1:** Quantitative course evaluation data for MSE 403 (Technology Entrepreneurship I), Spring 2015.

MSE 403 / BUS 404 (Spring 2015)	MSE Mean (Count)	BUS Mean (Count)
How often did you attend the lectures/seminars? (4 = always, 0 = hardly ever)	4.00 (14)	4.00 (4)
The course prerequisites were (4 = essential, 0 = not essential)	3.36 (11)	3.75 (4)
The overall level of difficulty of the course was (4 = too easy, 0 = too difficult)	2.00 (11)	1.75 (4)
The amount of work required for the course was (4 = too little, 0 = too much)	1.93 (14)	1.75 (4)
How valuable was the course content? (4 = very, 0 = not very)	3.93 (14)	3.75 (4)
The course text or supplementary material was (4 = relevant, 0 = irrelevant)	3.56 (9)	3.25 (4)
I would rate this course as (4 = highest, 0 = lowest)	4.00 (14)	4.00 (4)

The assignments and lecture/seminar were (4 = well related, 0 = unrelated)	3.93 (14)	4.00 (4)
The exams and assignments were on the whole (4 = fair, 0 = unfair)	4.00 (14)	4.00 (4)
The marking scheme was on the whole (4 = fair, 0 = unfair)	4.00 (14)	4.00 (4)

**Table 2:** Quantitative course evaluation data for MSE 404 (Technology Entrepreneurship II), Spring 2015.

MSE 404 / BUS 405 (Summer 2015)	MSE Mean (Count)	BUS Mean (Count)
How often did you attend the lectures/seminars? (4 = always, 0 = hardly ever)	3.87 (15)	4.00 (5)
The course prerequisites were (4 = essential, 0 = not essential)	3.38 (13)	3.80 (5)
The overall level of difficulty of the course was (4 = too easy, 0 = too difficult)	2.07 (15)	1.80 (5)
The amount of work required for the course was (4 = too little, 0 = too much)	2.13 (15)	1.80 (5)
How valuable was the course content? (4 = very, 0 = not very)	3.87 (15)	3.80 (5)
The course text or supplementary material was (4 = relevant, 0 = irrelevant)	3.50 (10)	3.00 (5)
I would rate this course as (4 = highest, 0 = lowest)	3.93 (15)	3.60 (5)
The assignments and lecture/seminar were (4 = well related, 0 = unrelated)	3.86 (14)	3.60 (5)
The exams and assignments were on the whole (4 = fair, 0 = unfair)	3.64 (14)	3.60 (5)
The marking scheme was on the whole (4 = fair, 0 = unfair)	3.73 (15)	3.60 (5)

### 3.3 Qualitative Course Evaluations

In addition to the quantitative course evaluation results provided in the preceding section, qualitative comments are provided below (quoted directly as provided, after aggregation by MSE administration into an anonymous database). As with the quantitative results provided above, only comments related to the course (and not the instructors directly) are included.

While many of the comments are positive in nature, some important constructive criticisms were received. As an example, the clear need to provide access to prototyping funds earlier in the program has resulted in a revision to the program and significant acceleration of this process for the 2015/2016 cohort.

### MSE 403 (Spring 2015)

*What do you consider to be the strongest and weakest features of the instructor, as a teacher?*

- Amazing opportunity, I've learned so much and very glad I decided to join Tech-E Thank you!
- 10/10 would do again
- Great learning experience
- Excellent course

*What do you consider to be the strongest and weakest features of the course?*

- Course was well layed [sic] out, learned a lot
- MSE 403 was great and further developed my interest in entrepreneurship courses
- This course has been an excellent course. It has opened our eyes to entrepreneurial endeavours. Both instructors were very motivational. Parels [sic] were fantastic learned pitching skills!

*Any other comments or suggestions?*

- Never thought I'd do a dragons den style Pitch
- Thanks! This course will definitely be missed
- More money should be allocated for prototyping because components are expensive. Great course otherwise

### MSE 404 (Summer 2015)

*What do you consider to be the strongest and weakest features of the instructor, as a teacher?*

- Tech-E was a great experience and I will take the knowledge that I have picked up here as I enter the workplace and even work towards my own ventures!
- Great advice and mentorship given on how to handle starting a business
- Kind of a weird course, couldn't think of any legitimate comments or criticism
- By far this was the most valuable class I have taken. I learned so much about business & entrepreneurship well run, valuable content, A++

*What do you consider to be the strongest and weakest features of the course?*

- About the course, I felt the final presentation day (even though voted on) was poorly chosen and did not consider the additional obligations we have to take on course wise. If it had been the last day then it would have been the most fair.
- Amazing course overall, the prototyping funds, advice, and support helped our business grow. I [sic] suggestion I have is to schedule 1 on 1 time with teams.
- Fantastic simulation and entrepreneurship development program, providing an opportunity for real ventures to take off
- Extremely well thought-out deliverable & course work - none of it was cumbersome & none of it seemed useless

*Any other comments or suggestions?*

- The only criticism would be the need to get even a small amount of funding earlier

### **3.4 Key Stakeholder Metrics**

While the student experience and perspective (as discussed in the preceding sections) is highly important as a measure of program success, evaluation by other (e.g. external) stakeholders is also critically important. To this end, a number of metrics have been developed by the program's key stakeholders (including its funding partners). These include the following:

- Have multi-year mentorship relationships been established for each team?
- Have program workshops, networking and team-building events been executed as designed?
- Have student teams been actively introduced to appropriate sources of start-up capital?
- Has sector-specific market guidance been provided in key areas including sustainable energy, health sciences / biomedical Devices, information and communication technologies?
- Has an international component been established, with the aim of leading to a global collaborative network?
- Have cross-over courses been delivered as designed?
- Have industry panel presentations been delivered as designed?

These metrics are reported out to the external program stakeholders on a semi-annual basis. The program co-directors aggregate event records, statistics and status updates from the current and prior cohorts, which are included in a summary report that is prepared by faculty administration for dissemination and review. Ongoing revisions to the program and corresponding budget are also communicated and reviewed through this mechanism. Further, one of the key stakeholder organizations (BCIC) administers an online survey that is distributed to the participating students, completed and submitted directly to BCIC.

### **4. LONGER TERM PROGRAM METRICS**

Ultimately, the long-term success of the Tech-e@sfu program will be measured in terms of companies formed, and/or alumni actively engaged in fruitful entrepreneurial activities as a result of the training and experiences associated with the program. To this end, the following two metrics are additionally reported to key stakeholders on a semi-annual basis:

- Business Teams Directed into Accelerator
- Companies Formed

Student teams in the 2014/2015 and 2015/2016 cohorts have pursued projects in the domains of medical and medication management devices, automated image acquisition and processing for agricultural and oil & gas applications, automated lighting for entertainment productions, automated equipment for aquarists, automated home-brewing, sport-specific training aids and assistive hearing devices. As of April 2016, one alumni team has incorporated and is a going concern, while two others have moved into an SFU Venture Connection incubation phase. Additionally, several program alumni have begun working together on an entrepreneurial initiative that was created outside the scope of the program, i.e. are making fruitful use of their experiences, training and network developed in concert with the program objectives.

## 5. CONCLUDING REMARKS

The Technology Entrepreneurship @ SFU program is now in its fifth year as a collaborative endeavor between the School of Mechatronic Systems Engineering and Beedie School of Business, with three cohorts having completed the program, one in progress and another about to begin. Direct feedback from program participants has been used to make significant adjustments to the current program design. This has included the deployment of a multi-year program with a concerted effort to develop a community amongst the participating students, sharing a common language and trust, before asking them to select project teams. Other areas of focus have included active guidance, mentorship, coordination, communication and progressive project funding mechanisms.

Course evaluation and enrollment data, along with key stakeholder metrics, indicate that the program is realizing a degree of success in providing the interdisciplinary and entrepreneurial experience and training that is desired. Further, early indications of continued activity (past program completion) indicate that there is a potential for successful results from a longer-term perspective.

Further development is likely to focus on enhancing the pathway for students as they emerge from the Tech-e@sfu program, and in particular providing more clearly identifiable and robust mechanisms to facilitate continued efforts in pursuing projects that have been started within the program, or coalescing around new ones.

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