Integration of Entrepreneurship in a First-Year Engineering Course

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Abstract

This evidence based practice describes the integration of entrepreneurship into a project-based first-year engineering course to encourage student innovation, and to develop student leadership and self-efficacy. A module featuring a series of lectures on entrepreneurship and business plan development was introduced as part of the curriculum. The module was further enhanced with the introduction of multiple company founders and industrial leaders who were invited to deliver presentations and interact with students regarding operations of engineering corporations and their paths to entrepreneurial success. Students were required to present in teams on a new business idea related to the assigned engineering project of the course. Student learning was also assessed through surveys on the impact and effectiveness of integrating the entrepreneurship component into the first-year engineering class.

Introduction

Today, numerous technology companies established by engineers are leading innovation and economic growth of the nation, which simultaneously strengthens the global economic leadership of the U.S. in science and engineering. However, many developing nations are rapidly developing their work forces in high tech fields and gaining comparative advantage in science and engineering[1]. In addition, globalization has introduced more job opportunities abroad along with intense competition for employment. Thus, it is more likely that American students will see more competition for employment opportunities[2]. The challenge of how to enhance student competitiveness and competency for a global market propels the continuous reformation of improvement in engineering education. Research studies have shown that providing entrepreneurship education could broaden student career choices and perspectives, and provide an alternative career path for graduates[3-4]. Motivated by the significant roles of engineers transferring technology to industry, during the last two decades, hundreds of programs with diverse approaches in entrepreneurship education have been implemented among universities to prepare undergraduate engineering students with entrepreneurial mindsets[5]. Students exposed to entrepreneurship focused courses demonstrate higher levels of self-efficacy and motivation, which in return, can potentially lead to successful entrepreneurial ventures making an impact on the nation's economic growth. Even for those who do not intend to create companies, entrepreneurship education is still a valuable medium for future graduates to develop and adopt an entrepreneur-like mentality toward innovation and creativity, accompanying with appropriate knowledge and skills[6].

Existing undergraduate programs offer a variety of methods to incorporate entrepreneurship education including offering degree certifications such as major, minor or concentration, presenting a sequence of engineering or technology focused entrepreneurship courses in current curriculum, collaborating with business school to lead in-class trainings and extracurricular activities such as business competitions, etc[5,7,8]. Among non-degree, course sequence focused programs, although the practices are often engineering theme focused, entrepreneurship education is seldom offered at the first year level as part of a design course where students design, build and test a tangible product.

We report on the practice of integrating a module featuring a series of lectures on entrepreneurship and business plan development into an existing first-year engineering course. This two-quarter Introduction to Engineering course provides a team-based experiential learning experience to first year students focused on design process and product development. Since the first-year course has not been approved as a required class, but only as an elective for all engineering disciplines, we selected projects more relevant to technologies ubiquitous in popular culture in order to increase student enrollment. The projects currently implemented are quadcopters with autonomous functions, fitness trackers (inspired by wearable technology) and lab-on-a-chip devices for point-of-care medical diagnostics. Due to the relevance of these products to current industry and technology trends, students are encouraged to develop a business idea in teams directly related to their design project. Some may question whether freshmen students have enough relevant engineering knowledge to create a technology-focused business idea. However, in this course, since sufficient theoretical background and practical experiences are both provided for students to make informed design choices, students are capable of obtaining relevant engineering foundations and skills necessary to complete the project. Therefore, by understanding the technical aspects, students may have a practical and unique perspective of the competitive advantage of such products rather than a purely paper-based idea. In order to encourage creativity, students are allowed to formulate business ideas in addition to the specific autonomous task required of the design project. Students were not required to construct separate prototypes due to time constraints and course workload.

The impact of the course including the entrepreneurial module was assessed through student surveys on course satisfactions and learning outcomes. Assessment results were compared for the 2015 and the 2016 class to evaluate course improvement. In addition, a demographic question on gender was added to the survey to assess the impact of learning outcomes for female students evaluated in comparison to male students for the 2016 class.

Course Implementation

Due to extensive instructions on engineering design process and theoretical background of the hands-on project during the first quarter, we introduced the module of entrepreneurship and business plan development only during the second quarter. Among a total of 10 in-class lectures, five of the lectures were assigned to the entrepreneurial module. The first three lectures on entrepreneurship were integrated into the course to allow students to develop an entrepreneurial mindset and a basic understanding on the business aspects of engineering. Specific topics include the following:

- Overview of entrepreneurship and small businesses
- Identifying major characteristics of entrepreneurs
- Learning the basics of business plan terms and planning
- Funding Landscape and Options
- Resources (On-campus)

Every student team is required to deliver a group presentation on a business idea formulated based on the design project. The presentation must include the following sections:

- Executive Summary
- Business Overview

- Marketing Overview
- Organizational Overview
- Financial Overview

During Winter Quarter of 2015, these three in-class lectures were entirely taught by guest instructors from the Blackstone LaunchPad/Entrepreneurial Center on campus. Since the speakers were not involved in planning or implementation of the design project, the instructional team observed a disconnect between the entrepreneurship module and the rest of the design course, which might cause the course to be segmented. Therefore, during Winter Quarter of 2016, the entrepreneurial module was taught by the instructor of the design course in order to bridge the gap between the engineering design project and how to apply the principles and knowledge of generating a business plan. Lectures were modified to be more directly applicable to the design project.

Throughout the two-quarter course, we engaged multiple industry speakers and start-up founders for class presentations regarding engineering design, career options, and cutting-edge research and technology to encourage interaction and participation of the first-year students with industry leaders. Therefore, besides the three instructional lectures on entrepreneurship, we invited successful start-up founders to share their career paths, vision, and business venture stories with the students focusing on how to apply the principle of writing a business plan to their product for the remaining two lectures. Interaction with these industry speakers allow students to witness innovative real-world examples and understand the practicality of such exercise of developing a business plan.

Methodology of Assessment

A course evaluation was administered to the class, given at the end of the Winter Quarter of 2015, and Winter Quarter of 2016 respectively, to assess the effectiveness of integrating the entrepreneurship and business plan development. Student satisfaction on was evaluated by rating the following on a scale from 1 to 5, where 1 is “very dissatisfied”, 2 is “somewhat dissatisfied”, 3 is “neutral”, 4 is “satisfied” and 5 is “very satisfied”:

- Organization and Format
- Lecture notes/supplied material
- Overall rating on the Entrepreneurship Module

Two more questions were assessed using the same scale with a slightly different meaning for 1 to 5, 1 is "Very little, low", 2 is "Somewhat", 3 is "Average", 4 is "Moderate", 5 is "High".

- How interesting is the Entrepreneurial Module?
- How practical is the Entrepreneurship Module?

For statistical analysis, differences between two groups (2015 cohort and 2016 cohort) were tested by the Student’s *t*-test. Differences were considered significant if $p < 0.05$, to evaluate whether the changes implemented in 2016 enhanced student experiences.

The students were also expected to develop a basic understanding of how to define and create the separate components of a business plan. Therefore, as part of the course evaluation, students were asked to self-assess their ability/understanding by comparing the following aspects at the beginning and the end of quarter on a scale of 1 to 5, where1 is "Very little, low", 2 is "Somewhat", 3 is "Average", 4 is "Moderate", 5 is "High".

- Understanding the benefits of having a business plan
- Understand how to make a business plan
- Understand why a business plan is important
- Ability to list the components of a business plan
- Ability to find resources to use to start your business
- Confidence in starting your own business

Lastly, we asked students whether they would be interested in starting their own business in the assessment. For the class in 2016, we added one more demographic question of student gender in the beginning of the survey to compare the learning outcomes of female to male students in class since the course is heavily male populated (approximately 80%). Differences were considered significant if $p < 0.05$.

Results and Analysis

Student satisfactions were measured by the average score of organization and format, effectiveness of lecture notes/supplies materials, levels of interests on entrepreneurship, practicality, and overall rating of the module, using the scale described previously. 154 students participated in the Winter 2015 survey and 113 students participated in the Winter 2016 survey. As shown in Table 1, the mean value with standard deviation were listed for the 2015 and the 2016 cohort respectively. N represented the sample size which was the number of students who answered the particular question. P-value was also calculated to examine the differences between two groups. Both cohorts were satisfied with the implementation of the module. For all five aspects of the student satisfactions, the student experiences improved from 2015 to 2016 indicated by higher means in 2016, with all P-values < 0.05 where the difference was considered significant. With a more continuous approach of integrating the entrepreneurial module, student interests and perspectives on the practicality of entrepreneurial modules improved as well. Noteworthy is the fact that the 2016 group was an academically stronger cohort based on incoming high school GPA. Thus, in addition to the pedagogical modification, the enhancement of student experiences could also possibly be contributed to student academic preparedness.

Assessment Questions	**Mean ± Standard Deviation, N**			**p-value**
	Winter 2015	**Winter 2016**		
Organization and format	4.20 ± 0.72, 153	4.47 ± 0.75, 113		**0.0028**
Lecture notes/supplied materials	3.97 ± 0.81, 154	4.18 ± 0.88, 113		**0.045**
How Interesting is Entrepreneurship?	3.60 ± 1.05, 154	4.05 ± 1.03, 113		**0.00057**
How practical is the Entrepreneurship?	3.78 ± 0.96, 154	4.12 ± 0.96, 113		**0.0040**
Overall Rating, Entrepreneurship Module	4.07 ± 0.89, 154	4.32 ± 0.82, 113		**0.021**

Table 1. Comparison of entrepreneurial module aspects between Winter Quarter of 2015 and Winter Quarter of 2016.

In the same evaluation, students were also asked to self-assess their ability and understanding of the benefit, importance, process and components of formulating a business plan at the beginning and end of the quarter respectively. In addition, students were also required to rate their ability to find necessary resources to use for their business idea and their confidence in starting a business.

The survey results clearly demonstrated successful student learning outcomes on the assessed skills. As shown in Figure 1, higher average ratings with smaller standard deviation (error bars) at the end of the quarter (red) can be observed in comparison to the corresponding results at the beginning of the quarter (blue). Hence, the entrepreneurial module made a notable impact in facilitating student understanding of the business plan development process, and furthermore increasing student confidence in exploring the option of starting businesses.

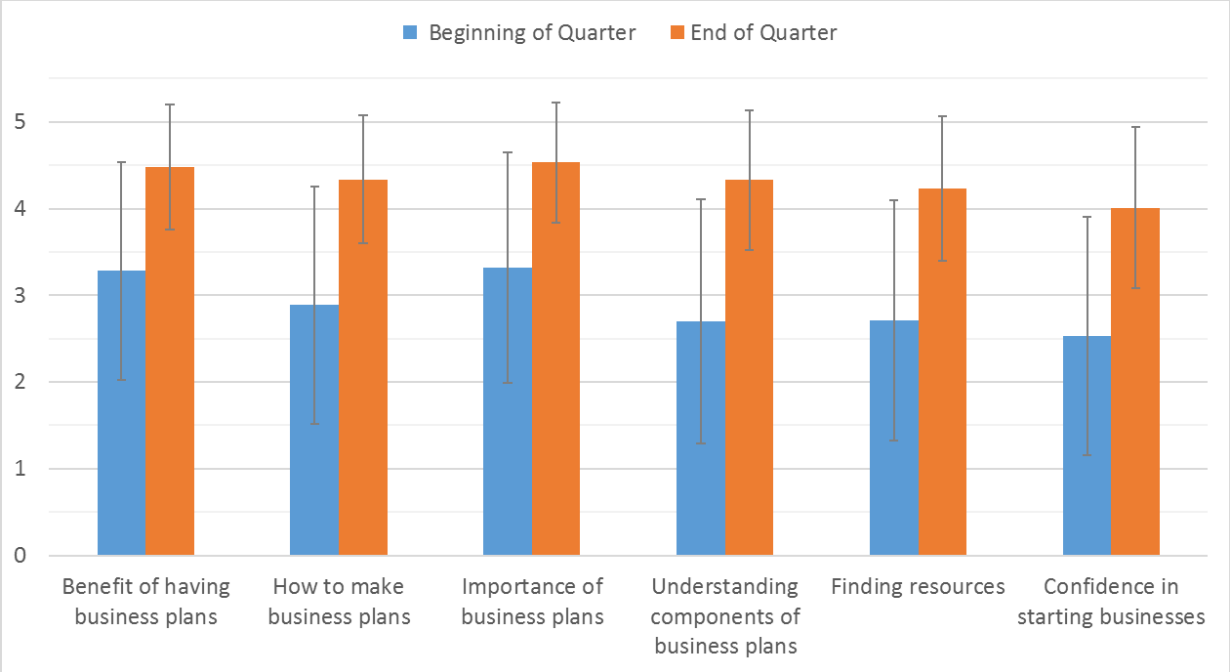

Figure 1. Student self-evaluation of learning outcomes of the entrepreneurial module for the Winter Quarter of 2016.

Since the course population was dominated by male students, we were concerned whether female student learning outcomes had been effected as a minority group. In the survey addressed to the 2016 class, students were asked to report their gender. 20 female students and 93 male students participated in the same survey. No significant differences were found among student satisfaction questions, but learning outcome differences were found among the self-assessed abilities related to business plans, and their confidence of finding recourses and starting businesses.

Table 2 shows the comparison between the male and female students displaying the mean value with standard deviation on the self-assessed ability/understanding of various perspective of business plans. N represented the sample size. P-value was also calculated to examine the differences between two groups. As shown in Table 2 indicated by P-value, besides the ability to

"understand why business plan is important", female students demonstrated significant differences ($p < 0.05$) in lower means of the self-assessed abilities in comparison to the male students at the beginning of the quarter. However, at the end of the quarter, the results of female students improved evidently exhibiting much closer mean values to those of male students. No significant differences were observed ($p > 0.05$) in most of the abilities/understanding evaluated, demonstrating the positive impact of the module in increasing entrepreneur knowledge among female students. The only significant difference observed ($p < 0.05$) between the two groups at the end of the quarter was the student confidence in starting a business. Although improved dramatically from the initial rating of 1.80 at the beginning of the quarter to 3.55 at the end of the quarter on a scale of 1-5, the female student cohort remained less confident in starting business in comparison to male students. Further study of focus group interviews may be arranged to understand the phenomenon.

Assessment Questions	Time	Mean ± Standard Deviation, N		p-value
		Female	Male	
Understanding the benefits of having a business plan	Beginning of Class	2.65 ± 1.08, 20	3.42 ± 1.25, 93	*0.012*
	End of Class	*4.25 ± 0.79, 20*	*4.52 ± 0.70, 93*	**0.12**
Understand how to make a business plan	Beginning of Class	2.00 ± 1.12, 20	3.08 ± 1.35, 93	*0.0012*
	End of Class	*4.15 ± 0.75, 20*	*4.38 ± 0.74, 93*	**0.22**
Understand why a business plan is important	Beginning of Class	2.90 ± 1.37, 20	3.41 ± 1.31, 93	0.12
	End of Class	*4.30 ± 0.80, 20*	*4.58 ± 0.66, 93*	**0.10**
Ability to list the components of a business plan	Beginning of Class	1.80 ± 1.11, 20	2.89 ± 1.39, 93	*0.0014*
	End of Class	*4.20 ± 0.89, 20*	*4.35 ± 0.79, 93*	**0.44**
Ability to find resources to use to start your business	Beginning of Class	1.80 ± 0.83, 20	2.90 ± 1.41, 93	*0.0010*
	End of Class	*4.00 ± 0.86, 20*	*4.28 ± 0.83, 93*	**0.18**
Confidence in starting your own business	Beginning of Class	1.80 ± 1.11, 20	2.69 ± 1.38, 93	*0.0082*
	End of Class	*3.55 ± 0.89, 20*	*4.11 ± 0.91, 93*	0.014

Table 2. Comparison of male and female student self-evaluation of learning outcomes of the entrepreneurial module. Mean and standard deviation are calculated. N represents the sample size. P-value is calculated to examine the differences between the two groups

Interested to start your own business?	Winter, 2015	Winter, 2016	Female Students Winter, 2016	Male Students Winter, 2016
YES	39%	60%	55%	61%
NO	61%	40%	45%	39%

Table 3. Survey results on student motivation on starting business

Students in the 2015 and the 2016 course were both inquired of whether they would be interested in starting their own business in the assessment survey. Table 3 showed the percentage of students who selected yes versus no. A larger percentage of students in the 2016 class showed interests in starting their own business comparing to the students in 2015. Both the module instructional improvement and the academic readiness of the 2016 group might have impacted this outcome positively.

Conclusion

This paper reports on the integration of entrepreneurial module into a first-year engineering design course in 2015 and 2016 respectively. The evaluation surveys demonstrated the success of implementation of such module based on student satisfactions and learning outcomes for both years. In comparison, student satisfactions were improved in 2016 by refining the instructional approach. Student understandings of business plans, ability to seek resources, and confidence in starting business, were assessed as well. The results illustrated that the module had successfully enhanced student interests and abilities in developing a basic understanding of entrepreneurial skills and mindset. The impact on student efficacy and motivation will be assessed further in future studies.

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