Examining the differences in the grade point average (GPA) for engineering students enrolled in entrepreneurial education programs

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Abstract

Undergraduate students in engineering continue to gain exposure to entrepreneurial programming through different entrepreneurship education programs (EEPs) initiated in higher education institutions. While traditionally, entrepreneurship education has been initiated and housed in business schools; recent programmatic offerings have increased in the engineering schools. Through various offerings (e.g., full-credit courses and seminars), engineering EEPs focus on developing entrepreneurially-minded engineering graduates to prepare them to succeed in their future career roles. While research in entrepreneurship education has demonstrated the positive impact of EEPs, there is a lack of understanding about students who enroll in these EEPs. Specifically, because students often self-select into different EEP programmatic offerings, differences in students who participate in the different programmatic offerings (i.e., business, engineering, seminar EEPs) needs research examination. This exploratory research paper addresses this gap in the literature. It examines the research question: what is the difference (if any) in grade point average (GPA) between engineering students who enroll in different EEPs? The data source includes GPA and enrollment records for 6156 undergraduate engineering students who enrolled in EEPs at a large research university located in the U.S. An analysis of variance (ANOVA) was conducted to examine the difference in GPA between students who enrolled in engineering EEPs (N = 1204), business EEPs (N = 2923), and EEP seminar (N = 2029). The ANOVA results identify statistically significant differences in mean GPA between the three groups. Post hoc tests show statistically significant differences in GPA between seminar and engineering groups, and seminar and business groups. No statistically significant differences were found between students enrolled in engineering EEPs and business EEPs. The results' implications and future work directions are discussed in the paper.

Introduction

Entrepreneurship Education Programs (EEPs) are a prominent platform for undergraduate students to gain exposure to entrepreneurship practices [1]. While traditional entrepreneurship education has focused on self-employment and venture creation, recent advancements have shifted the emphasis toward developing entrepreneurially-minded graduates. In particular, EEPs in engineering have evolved to focus on cultivating entrepreneurial skills and mindsets, expanding beyond sole enterprise formation [2]. These EEPs are posited as a means to foster innovativeness in students' chosen fields of employment upon graduation [3]. Moreover, engineering EEPs have advanced from business-oriented programs to more immersive, real-world-oriented approaches that aim to help students acquire entrepreneurship-related traits, skills, and mindsets [2]. Alongside existing EEPs offered by business schools, the number of EEPs offered by engineering colleges continues to grow, providing a range of programmatic offerings, such as project-based courses, seminars, minors, and co-curricular activities, specifically designed to prepare students for success in a technology-driven economy [4].

While research has shown the positive impact of entrepreneurship education on undergraduate engineering students in various student outcomes, such as career decisions, attitudes, academic performance, and retention, minimal attention has been given to understanding the differences in student participation between different programmatic offerings, such as business and engineering EEPs [5]-[7]. Given the increasing recognition of the role of EEPs in influencing engineering students' educational experiences, it is crucial to examine the self-selection of engineering students in EEPs. As institutions are likely to continue offering diverse EEPs to expose students to entrepreneurship programming, it is imperative to explore students' backgrounds in relation to their participation in different EEPs to better understand the pathways for developing entrepreneurially-minded engineers. Thus, the research question addressed in this study is: What are the differences in GPA between students who enroll in different EEPs?

In the subsequent sections of this paper, we review relevant literature, describe the methodology of our research, present and discuss the study's results in the context of its limitations, and highlight future research directions. Furthermore, we provide a more comprehensive explanation of the significance of our findings to underscore the contribution of this study to the field of entrepreneurship education in engineering.

Literature Review

Entrepreneurship education has undergone significant changes since its introduction to higher education in 1947 at Harvard University [8], [9] Initially focused on promoting self-employment and venture creation [10], entrepreneurship education has evolved to encompass a wider range of instructional techniques and designs, including a shift towards producing entrepreneurially oriented graduates with the knowledge and abilities to identify and seize opportunities [11], [12], particularly in engineering fields.

Specifically, in recent years, entrepreneurship education programs (EEPs) have seen a growth in popularity as universities have strived to enhance innovation and creativity training for engineering students [13], [14]. In the US, several STEM-centered national-level programs have been introduced, such as the National Science Foundation's Epicenter Program, the National Center for Engineering Pathways to Innovation, and the I-Corps Program [15]. These programs expose students and faculty to entrepreneurial activity and business knowledge through learner-centered techniques and designs offered through official co-curricular activities and curricular coursework.

EEPs can vary in intensity, type of delivery, and mentorship and can differ within and between disciplines such as business and engineering [13], [15], [16]. For example, engineering EEPs tend to focus more on innovation, while business EEPs emphasize working toward venture creation and imparting business knowledge [13]. For instance, North Carolina State University, a program founded in 1993, offers weekly seminars and team-based projects with an entrepreneurial focus unique to engineering [17]. On the other hand, capstone projects in business schools may have a more individualistic focus in the form of a written analysis of a business case study [17].

Although there is diversity among EEPs across schools, students at large institutions have the option to self-select their entrepreneurship education path, which may result in variability in learning outcomes and participation climate [7], [17], [18]. Prior research has explored the impact of student characteristics and the type of EEPs on their GPAs, with mixed results [7], [17]. Additionally, student background and learning demographics have been found to influence the type of entrepreneurship program students choose to engage in [19]. However, there is still a need for further understanding of the inner workings of different EEPs [20]. This motivates the current study to explore associations between characteristics of students who enroll in different types of EEPs, including business, engineering, and seminar EEPs throughout their undergraduate studies, to identify potential roadblocks and catalysts to diversifying engineering students' participation in different EEPs [20], [21], [22].

Methodology

Data Collection

Student enrollment data was gathered from the registrar's office at a sizable public research institution in the United States. Records of undergraduate students who received degrees from the College of Engineering between 2007 and 2018 were gathered to help define the scope of this study. The dataset is comprised of information about the enrollment of 15415 students in the number of credits for entrepreneurship classes provided by the College of Engineering and the Business School (dependent variable). In addition, information on the student demographics (gender, URM status, and academic GPA) was also acquired (independent variables). Table 1 lists the student's demographic data.

Data demography

The below table:1 shows the classification of students' data according to their race and gender. There are 3363 male students and 1163 females. Out of all the males, 79.98% chose Engineering, 71.98% chose business, and 82.93% chose seminar. For the females, 20.01% chose Engineering, 28.01 chose business, and 17.06% chose seminar. Considering the ethnicity of students who chose Engineering, 53.14% belonged to White, 26.76% belonged to Asian, 8.70% belonged to Not Indic, 4.23% belonged to Black, 3.98% belonged to Hispanic, and 3.09% belonged to 2 or More. In contrast, no students belonged to Native Amr or Hawaiian ethnicity. Of the students who chose business, 51.40% belonged to White, 27.77% belonged to Asian, 10.42% belonged to Not Indic, 2.70% belonged to Black, 4.32% belonged to Hispanic, and 3.26% belonged to 2 or More. 0.09% to Native Amr, while no students belonged to Hawaiian ethnicity. Of the students who chose the seminar, 55.11% belonged to White, 25.44% belonged to Asian, 8.28% belonged to Not Indic, 3.58% belonged to Black, 4.36% belonged to Hispanic, and 3.05% belonged to 2 or More. 0.14% to Native Amr, while no students belonged to Hawaiian ethnicity. The above-described data is shown in the form of the table below.

Demographic Classification	Engineering	Business	Seminar
Gender			
Male (n=3633)	79.98%	71.98%	82.93%
Female (n=1163)	20.01%	28.01%	17.06%
Ethnicity			
White(n=2569)	53.14%	51.40%	55.11%
Asian(n=1280)	26.76%	27.77%	25.44%
Not Indic (n=458)	8.70%	10.42%	8.28%
Black(n=150)	4.23%	2.70%	3.58%
Hispanic(n=185)	3.98%	4.32%	4.36%
2 or More (n=150)	3.09%	3.26%	3.05%
Native Amr (n=4)	0%	0.09%	0.14%
Hawaiian(n=0)	0%	0%	0%

Table 1. Demographic classification of the data of 4796 students

Statistical method

S Statistical software SPSS version 24 was used to analyze the data. First, generative descriptive statistics are used to develop a preliminary understanding of the data. Second, A One-Way ANOVA analysis is conducted. To ascertain whether there are any statistically significant differences between the means of three or more independent (unrelated) groups, the one-way analysis of variance (ANOVA) is utilized. The one-way ANOVA examines the means of the groups you are interested in and assesses if any of those means differ statistically. In particular, it evaluates the null hypothesis.

$$H_0: \mu_1 = \mu_2 = \mu_3 = \cdots = \mu_k$$

Where k is the number of groups and is the group mean. The alternative hypothesis (H_a), which states that at least two group means are statistically significantly different from one another, is accepted if the one-way ANOVA yields a statistically significant result. The findings of these studies are presented in the "Analysis and Results" section.

Results

Assumptions

This study analyzed one continuous dependent variable, students' grade point average (GPA), and one independent variable, enrollment, consisting of three categorical groups (Engineering, Business, and Seminar). The observations within each group and between the groups were independent. No significant outliers were found in the data after removing 24 outliers. The distribution of the dependent variable was found to be normal for each group, and the variances were determined to be homogeneous based on the results of Levene's test for equality of variances (p =.149).

Descriptive Statistics for each type of entrepreneurial course students registered

The following table (Table 2) gives the descriptive data for the 4797 students who have taken either Engineering, Business, or Seminar courses. First, 2923 students who chose the Business entrepreneurship course had a mean GPA of 3.35 and a standard deviation of 0.39. Next, 2029 students enrolled in the seminar entrepreneurship course had a mean GPA of 3.28 and a standard deviation of 0.40. Finally, 1204 students who opted for Engineering Entrepreneurship courses had a mean GPA of 3.33 and a standard deviation of 0.40.

Course Type	**Number**	**Mean**	**Standard Deviation**
Business	2923	3.35	0.39
Seminar	2029	3.28	0.40
Engineering	1204	3.33	0.40

Table 2. Descriptive data for the entrepreneurial course

ANOVA for GPA difference analysis

An ANOVA-based analysis is used to find significant differences in students' GPAs across the type of entrepreneurship courses they registered for. Students were classified into 3 groups: Engineering (n = 1204), Business (n = 2923), and Seminar (n = 2029). The ANOVA analysis depicted significant differences in students' GPAs for the different entrepreneurial courses, $F(2,6153) = 20.322$, $p<.001$, as shown in the table:3 below.

ANOVA **GPA**					
	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	6.52	2	3.263	20.32	<0.001
Within Groups	987.82	6153	0.161		
Total	994.35	6155			

Table 3. ANOVA table for the data

While the GPA was higher for business (3.35 ± 0.3) followed by Engineering (3.33 ± 0.4) and the lowest for the seminar (3.28 ± 0.4), Tukey Post Hoc analysis examined which pairs were different in GPA. The results show that the GPA difference between the engineering and seminar groups, and the business and seminar groups were statistically significant (p=<.001). No Significant differences between engineering and business groups were found (p > 0.05). The results of the Tukey Post Hoc Analysis are shown in Table 4 below.

Multiple Comparisons

Dependent Variable: GPA

95% Confidence Interval

	(I)ENTR_COURSE	(J)ENTR_COURSE	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Tukey HSD	Engineering	Business	-0.01	0.01	0.42	-0.04	0.01
		Seminar	0.05*	0.01	<0.00	0.02	0.08
	Business	Seminar	0.07*	0.01	<0.00	0.04	0.10

Table:4 Tukey Post Hoc Analysis

*. The mean difference is significant at the 0.05 level.

Further analysis and methodological discussion

The present study investigated the differences in GPAs among engineering students who enrolled in engineering, business, or seminar entrepreneurship courses. The results of the ANOVA and Tukey Post Hoc analysis showed that there were significant differences in GPAs between business and seminar students compared to those in engineering and seminar courses. However, no significant difference was found between the GPAs of engineering and business students. These findings provide valuable insights into student participation in entrepreneurship education programs and highlight the importance of examining student demographic and academic factors to understand engineering students' engagement and devise steps to promote 'self-select' entrepreneurship courses to diverse student groups.

While the results of this study contribute to our understanding of the relationship between entrepreneurship education participation and student GPA, our findings are limited to due to small effect sizes, and lack of detailed understanding from a practical standpoint. To accomplish this, we suggest further analysis using advanced statistical techniques, such as classification and regression trees, to provide a more comprehensive understanding of student GPA's impact on participation. Leveraging advanced data analytics techniques, such as machine learning, to develop a prediction model for forecasting student enrollment in EEPs. For example, to achieve this, we utilized a decision tree-based approach to predict student enrollment based on their GPA. An example of three representative rules from the decision tree is summarized in Table 5. If a student's GPA is less than or equal to 2.461, their predicted enrollment is engineering EEPs (***E***), if student GPA is between 2.812 and 3.008, then, the predicted enrollment is engineering and business EEPs (***BE***). Finally, if a student's GPA is between 3.006 and 3.008, their predicted enrollment is business EEPs (***B***).

Enrollment prediction	GPA
$\boldsymbol{E}$ (Engineering EEPs)	Less than or equal to 2.461
$\boldsymbol{BE}$ (Enginering and business EEPs)	Between 2.812 to 3.008
$\boldsymbol{B}$ (Business EEPs)	Between 3.006 to 3.008

Table:5 Summary of decision rules

Conclusion and future work

In conclusion, this study contributes to the literature on entrepreneurship education and provides insights into the relationship between the type of entrepreneurship courses and GPA among engineering students. The findings have implications for entrepreneurship education policy and practice, and future research can build on these findings to further advance our understanding of entrepreneurship education outcomes and inform strategies for promoting entrepreneurship education among engineering students. Additionally, to improve generalizability and facilitate comparisons across different institutional settings, future studies could be conducted at various institutions, considering factors such as Carnegie classification, student enrollment size, teaching/research focus, and HBCU/HSI (Historically Black Colleges and Universities/Hispanic-Serving Institutions) status. Furthermore, it would be valuable to explore other student-level factors beyond GPA that may inform participation in entrepreneurship education programs. For example, factors such as demographic characteristics, prior entrepreneurial experience, and motivation for entrepreneurship could be considered in future research. Understanding these factors could help in developing targeted strategies to promote entrepreneurship education among engineering students and facilitate their entrepreneurial success.

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