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Instilling an Entrepreneurial Mindset in a New Generation of First-Year Engineering Students Through a Graphics Course Project

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Abstract

Each year, an increasing number of engineering start-up companies emerge in the U.S. and around the world. Innovation and entrepreneurship have never been so pronounced, especially in science, technology, engineering, and mathematics (STEM) fields. How can we train engineering students to be more entrepreneurially-minded so they are well-equipped to become global innovators? Engineering educators can use entrepreneurially-minded learning activities to help students develop an entrepreneurial mindset, which is a set of beliefs, attitudes, and behaviors. At a mid-sized Southeastern private institution, we used an open-ended team project and an end-of-semester poster competition within a freshman-level engineering graphics course to encourage an entrepreneurial mindset in students. The goal of the course project was to develop engineering students' critical thinking and innovation skills while preparing them for their future professions. An end-of-semester course-wide poster competition allowed students to practice teamwork as well as innovative thinking and communication skills. An online survey was conducted during the student poster competition to assess students' understanding of entrepreneurial mindset and satisfaction with the student poster competition.

Introduction

Many college professors are still trying to adjust their curriculum to meet the needs of millennials. In recent years, 72 percent of high school students and 64 percent of college students have expressed eagerness in starting a business (Schawbel, 2014). In fact, 61 percent of high school students and 43 percent of college students would rather be an entrepreneur instead of an employee after they graduate college (Schawbel, 2014). Now, students from Generation Z are attending U.S. institutions and presenting new demands for higher education. Generation Z consists of students who were born after millennials, in the mid to late 1990s (Moore, Jones, & Frazier, 2017). Many students from Generation Z are even more self-reliant and career driven than previous generations (Kozinsky, 2017). For example, 13% of Gen Z-ers already have their own business (Kozinsky, 2017). On average, Generation Z is more independent than millennials and they are prepared to make their own decisions based on information they find on the internet (Malat, 2016). To do research and teach themselves, Gen Z-ers rely on internet tools such as Google's search engine and YouTube.

As college instructors, what can we do to help develop or improve engineering students' entrepreneurial mindset? How can we sharpen students' critical thinking and innovation skills? How can we better prepare students for their future professions? To answer these questions, we used an open-ended

team project within a freshman-level engineering graphics course to encourage an entrepreneurial mindset in students. An end-of-semester course-wide poster competition allowed students to practice teamwork as well as innovative thinking and communication skills. This paper will describe the results of an online survey from the student poster competition, which assessed students' understanding of entrepreneurial mindset and students' satisfaction with the poster competition.

Course Curriculum and Description

In this study, the chosen freshman-level engineering graphics course was designed to familiarize students with the basic principles of drafting and engineering drawing, to improve three-dimensional (3-D) visualization skills, and to teach the fundamentals of computer-aided design (CAD). Classes met in a computer laboratory twice a week for one hour and forty-five minutes to fulfill the requirements of the three credit-hour semester-long course. Students completed an open-ended design project and worked in self-selected teams of two to four. Students had to design an existing product and then considered how to improve it. Students received approval from their instructors regarding their design idea along with their innovative and creative methods for solving the problem. Many students incorporated sustainability concepts into their design, which involves engineering design feasibility, environmental impact, social and political consideration, and economic and financial feasibility. To address the importance of sustainable design, students were shown example CAD parts or they watched a series of screencasts by Autodesk (Menter, 2011) that contained real-world sustainable design examples.

Throughout the semester, instructors served as facilitators to ensure that student projects were completed on time. However, direct guidance was limited. Specific class time was dedicated to the project so students could collaborate with their teammates and work on the project. Students were encouraged to think outside of the box and systematically design their project. Before the last day of class, students submitted all project deliverables such as team design report, dimensioned drawing sheets, 3-D parts, assembly, and PowerPoint slides. On the last day of the class, students wore business casual or professional attire to present their work as a team. Each presentation lasted 8-10 minutes, and was followed by 2 minutes of question and answer time (Long & Jordan, 2016; Long & Sun, 2018).

Students completed confidential peer evaluation forms in order to evaluate their own performance and that of their teammates. Criteria was considered such as contribution and quantity of work, interaction and collaboration of the team, problem-solving skills and quality of work, time management, and willingness to be a team player. During the oral presentations, students completed a team evaluation for other groups in the class. Criteria were evaluated such as organization, slide content and aesthetics, presentation skills, and team member participation. Students were strongly encouraged to leave comments, as well as

recommendations, to support their evaluation. At the end of the presentation, the instructor summarized the student projects and the top two teams were selected to attend the end of semester student poster competition for all sections of the course. Selected student teams made posters and presented their work to students and faculty on campus. During the poster competition, judges included graduate students, past student winners as well as faculty and staff from CNC and Welding Lab, Center of Teaching and Learning Excellence (CTLE), Digital Studio, and Office of Undergraduate Research. Student teams competed for 3-D printed medals and different awards such as best poster design, most sustainable design, most sophisticated design, best presentation, people's choice award, and the best of the best award. Figure 1 includes images of 3-D printed medals, award certificates, and a student team's poster.

Comment [L1]: This acronym needs to be defined.

Figure 1: Student poster competition along with certificates and 3-D printed medals

Course Feedback

Data collection. Prior to the EGR 120 End-of-Semester Poster Competition, a survey was developed based on items from the *Engineering Entrepreneurship Survey* (Duval-Couetil, Reed-Rhoads, & Haghighi, 2011). The survey included Likert-scale and open-ended questions. Some questions used a 5-point scale from *poor* to *excellent* to have students rate their skill levels in areas such as communication skills and presentation skills. The survey also included several questions about student demographics. For example, students were asked to provide their major, sex, ethnic/racial background, etc. Lastly, the survey contained additional Likert-scale items as well as some open-ended questions, which allowed students to uniquely describe what they did and did not like about the poster competition.

Sample and population. Of the 52 students who presented 19 posters and participated in the Spring 2018 poster competition, 37 students completed the survey. Based on responses to demographic survey items, over 70% of students who completed the survey were aerospace engineering majors, while less

than 19% were majoring in mechanical engineering, more than 8% were studying civil engineering and nearly 3% were pursuing a degree in computer science. In addition, approximately 81% of students who completed the survey were male and over 51% were out-of-state students. Lastly, over 75% of students who completed the survey were White, over 16% were Hispanic or Latino, more than 5% were Asian, nearly 3% were multi-racial and nearly 3% did not want to disclose their ethnic/racial background. As of Fall 2017, undergraduate students from the Southeastern campus are 56% White, 22% female, 13% international students, 7% multi-racial, 5% Black, 5% Asian, 7% Hispanic, and 33% in-state students with an average age of 21.

When completing the survey, students answered several questions concerning their level of agreement about the poster competition. On average, students thought components of the poster competition were between *good* to *very good*. Students' mean level of agreement regarding the overall poster competition was 3.77 (SD=0.61), on a scale of 1 = *poor* to 5 = *excellent*. Students' mean level of agreement regarding the organization of the competition was 3.61 (SD=0.90), while it was 3.29 (SD=0.96) for information provided before the competition and 3.19 (SD=1.03) for length of competition. Student responses to open-ended questions about what they liked and didn't like about the poster competition provided additional insight. Multiple students said they liked the "variety of projects" or "diversity of project ideas." On the other hand, some students thought the competition was "kind of long" or "too long," especially while "standing." Table 1 and Figure 2 below contain additional details regarding students' level of agreement about the poster competition.

Table 1: Students' level of agreement about the poster competition

	M	**SD**
Overall Poster Competition	3.77	0.61
Organization of Competition	3.61	0.90
Information Provided before Competition	3.29	0.96
Length of Competition	3.19	1.03

Figure 2: Students' level of agreement about the poster competition

When responding to survey items about skill level, over 50% of students believe their communication skills, presentation skills, analytical skills and ability to evaluate business ideas are *average* to *excellent*. At more than 86%, the highest percentage of survey participants believed their analytical skills are *above average* or *excellent*, which resulted in a mean value of 4.05 (SD=0.57) on a scale from 1 = *poor* to 5 = *excellent*. At over 51%, the lowest percentage of survey respondents believe their ability to evaluate business ideas is *above average* or *excellent*, which led to a mean value of 3.62 (SD=0.82). Table 2 and Figure 3 include a visual representation of students' skill levels in the aforementioned areas.

Table 2: Students' perceived skill levels

	M	SD
Communication skills	3.95	0.70
Presentation skills	3.76	0.82
Analytical skills	4.05	0.57
Ability to evaluate business ideas	3.62	0.82

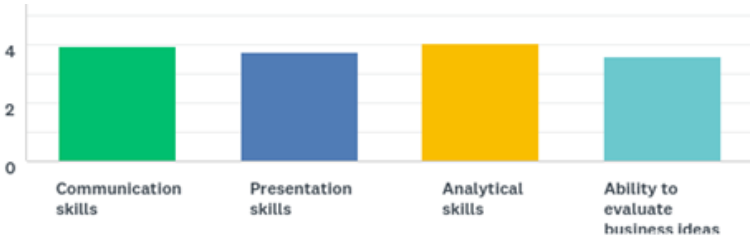

Figure 3: Students' perceived skill levels

As previously mentioned, several survey questions addressed entrepreneurship. On average, students have taken an average of 0.16 (SD=0.44) entrepreneurship courses outside of engineering. Over 86% of survey participants indicated that they have taken zero entrepreneurship courses outside of engineering while less than 11% have taken one and close to 3% have taken two entrepreneurship courses outside of engineering. Table 3 and Figure 4 provide further information about students' past entrepreneurship courses.

Table 3: Students' number of past entrepreneurship courses, outside of engineering

	M	**SD**
Number of classes	0.16	0.44

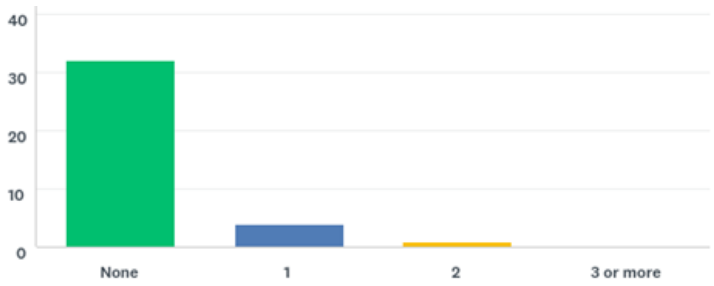

Figure 4: Students' number of past entrepreneurship courses, outside of engineering

While taking the survey, students also answered several questions concerning their level of agreement about entrepreneurship and their engineering classes. Over half of all student participants *agree* or *strongly agree* that students are encouraged to consider starting their own companies in their engineering classes, with a mean value of 3.44 (SD=0.92) on a scale from 1 = *strongly disagree* to 5 = *strongly agree*. More than 55% of students *agree* or *strongly agree* that in their engineering courses (a) faculty discuss entrepreneurship, (b) students are taught entrepreneurial skills, (c) students are encouraged to take entrepreneurship courses and (d) students are encouraged or required to participate in entrepreneurship-related activities. Student responses produced mean values of 3.41 (SD=0.95), 3.37 (SD=0.99), 3.33 (SD=1.09), and 3.52 (SD=0.96). An even larger percentage of students, at over 66%, *agree* or *strongly agree* that students are encouraged to develop entrepreneurial skills and there are opportunities to interact

with entrepreneurs in their engineering classes, with mean values of 3.63 (SD=1.06) and 3.59 (SD=1.03). Lastly, over 81% of participants *agree* or *strongly agree* that in their engineering courses students should learn more about entrepreneurship, with a mean value of 4.00 (SD=0.82) or a rating of *agree*. Table 4 and Figure 5 include a visual representation of students' level of agreement around these categories.

Table 4: Students' level of agreement about entrepreneurship and their engineering classes

	M	SD
Faculty discuss entrepreneurship	3.41	0.95
Students are taught entrepreneurial skills	3.37	0.99
Students are encouraged to develop entrepreneurial skills	3.63	1.06
Students are encouraged to take entrepreneurship courses	3.33	1.09
Students are encouraged or required to participate in entrepreneurship-related activities	3.52	0.96
Students are encouraged to consider starting their own companies	3.44	0.92
There are opportunities to interact with entrepreneurs	3.59	1.03
Students should learn more about entrepreneurship	4.00	0.82

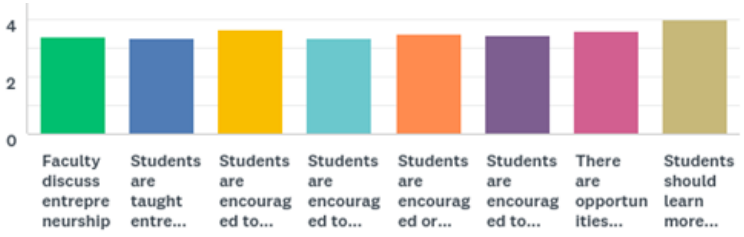

Figure 5: Students' level of agreement about entrepreneurship and their engineering classes

Table 5 and Figure 6 show that students answered several questions concerning their level of agreement about entrepreneurship and the poster competition. Nearly 78% of students *agree* or *strongly agree* they have a general interest in the subject of entrepreneurship with a mean value of 3.93 (SD=0.94), while using a scale from 1 = *strongly disagree* to 5 = *strongly agree*. More than 74% of students believe that entrepreneurship education can broaden their career prospects and choices at a mean value of 3.78 (SD=0.99). Over 70% of students *agree* or *strongly agree* they want to learn about entrepreneurship in their engineering courses and they want to know if they have what it takes to become entrepreneurs, leading to mean values of 3.78 (SD=1.03 and 3.67 (SD=1.02). Lastly, more than 59% of students *agree* or *strongly agree* they want to become entrepreneurs, are interested in taking entrepreneurship classes, and have ideas for a business product or technology, resulting in a mean values of 3.67 (SD=0.94), 3.56 (SD=0.94) and 3.63 (SD=0.94).

Table 5: Students' level of agreement about entrepreneurship after participating in the poster competition

	M	SD
I have a general interest in the subject of entrepreneurship	3.93	0.94
I want to become an entrepreneur	3.67	0.94
I have an idea for a business product or technology	3.63	0.82
I would like to know if I have what it takes to be an entrepreneur	3.67	1.02
I am interested in taking entrepreneurship classes	3.56	1.03
Entrepreneurship education can broaden my career prospects and choices	3.78	0.99
I would like to learn about entrepreneurship in my engineering courses	3.78	1.03

Figure 6: Students' level of agreement about entrepreneurship after participating in the poster competition

Conclusion and Recommendations

This paper described a generation change among students taking a freshmen-level engineering graphics course. The paper mentioned how to improve generation Z's entrepreneurial-mindset and business skills by implementing an open-ended team project and end-of-semester poster competition. The open-ended team project offered students an opportunity to learn the type of design engineering that emphasizes environmental, economic, and social responsibility. It also gave students an opportunity to inquire into, collaborate on, design, assemble, and present their work. An engineering entrepreneurship survey was used to assess students' perceptions of the graphics course-wide poster competition and overall project. Results indicate that the poster competition and overall project provided students with a positive and satisfactory experience, which enabled them to develop and practice critical thinking, innovation skills, and improve their interests in entrepreneurship. Students were able to think "outside of

the box" and solve real-world problems, which help improve their business skills as engineering students and enable them to ultimately solve challenges within their future companies, country, or even the world (Mekemson, 2010).

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