Entrepreneurial Curriculum in an Engineering Technical Communication Course: Looking for Impact on Creativity and Mindset

Benjamin J. Call, Wade H. Goodridge, Melissa Scheaffer
Department of Engineering Education
Utah State University
Logan, UT
Email: ben.call@aggiemail.usu.edu, wade.goodridge.usu.edu, melissa.sch@usu.edu

***Abstract*—This work in progress initiated an investigation into an intervention focused on entrepreneurial training that was implemented in the delivery of a "Technical Communication for Engineers" course at a western research university. The course was delivered through multiple separate sections and was taught by two instructors using the same curriculum. The control-group approach utilized an established method to help engineers and computer scientists learn technical communication by writing a technical proposal as a team. The treatment-group approach included providing entrepreneurial training and consulting through lectures and one-on-one consultations provided by student consultants from the university's Entrepreneurship Club. Student consultants were trained in Glauser's NERCM principles for business consulting. The impact measurement of the intervention focuses on the results of students taking the Abbreviated Torrance Test for Adults (ATTA) creativity assessment and Dweck's growth-vs-fixed Mindset survey. Lagged regression in quasi-experimental statistics will be utilized to compare results from a pre- and post-delivery of the test instruments taken before the entrepreneurial lectures begin and then again at the end of the course. Random selection of students from a convenience sample with an opt-out enrollment process was utilized. Additionally, a task value survey and an entrepreneurial intent survey were given to the students to develop an understanding of their views of this teaching method based upon the perceived value of the course.**

I. Introduction

Interest in increasing entrepreneurial training within engineering education has been growing, and many methods for achieving that combination are being developed [1]. Ultimately, the various methods will be judged by their impact on student development. It is hypothesized in this study that not only will entrepreneurial intent be impacted, but also broader characteristics like creativity and growth mindset. Literature indicates that these two characteristics can be developed and may be impacted by course instruction [2] [3] and this work looks to understand the strengths of any correlation between entrepreneurial training and creativity or mindset. In an effort to investigate the impact of entrepreneurial instruction, a class was identified with a professor and content that could readily accept instruction related to entrepreneurship. This investigation effort was facilitated using an approach that was designed to introduce the entrepreneurial topics while adding minimal increased workload on the existing curriculum and instruction already in place in the course. Such a focus is important for any application of additional content into existing intensive courses developed to maximize educational impact to students taking them. Student entrepreneurship consultants from the on-campus Entrepreneurship Club were brought in as peer instructors and business consultants to purposefully explain process of recognizing and realizing business opportunities to students while additionally advising the course's students in relation to their class projects. This research targeted a desire to discover the impact of the instruction on students' entrepreneurial intent. To address this objective, this study proposed the following research question: Does providing engineering students with limited peer-delivered entrepreneurial consulting impact their interest in entrepreneurship, their open-mindedness about opportunities, their creativity, and their mindset?

This work in progress paper addresses the motivation and methodology planned for a study comparing two instructional methods for a "Technical Communication for Engineers" course. One instructional method consisted of an existing traditional teaching approach while the other method involved bringing in student entrepreneurship consultants to present entrepreneurial content and advise students on their projects. Just as [1] looked at how entrepreneurial education can support the ABET criteria, this research reflects the desire to evaluate impacts that learning about entrepreneurship has on perspectives that are not necessarily specific to entrepreneurship, namely creativity and mindset. The work therefore evolves the motive found in previous work directed at promoting involvement of entrepreneurship in engineering courses to one of substantiating its impact on important education constructs. Quantitative measures for entrepreneurial intent, creativity, and growth mindset are being collected in a pre- and post-test approach. Additionally, interviews with a subset of student volunteers are being recorded for qualitative analysis.

II. Course Background

The Technical Communication for Engineers course provides a realistic exposure to the technical communication

demands faced by engineers. The goal of this course is to prepare engineering students with the individual and collaborative technical writing and presentation skills to be effective technical communicators in academic and professional environments. Emphasis is placed on writing technical, business, and professional documents most commonly found in industry and academia. The course culminates in the development of a final project, which includes a team-written proposal and presentation. Assignments submitted throughout the semester correlate with and contribute to the final project and include status reports, white papers, process/mechanism descriptions, letters of transmittal, technical resumes, and technical slides. Course lectures are primarily focused on writing grammatically-correct, properly-scoped proposals, other professional documents and presentations.

This proposal assignment challenges students to work collaboratively to develop an idea for a new technology that addresses one of the Grand Challenges for Engineering [4]. This focus expands students' awareness of the challenges facing 21st century engineers and allows them to think about the design process as they brainstorm and identify a technology that is feasible, cost effective, and credible. The final project lends itself to research on entrepreneurial intent as students are encouraged to identify topics that could be marketable.

A variety of pedagogical approaches are used in the delivery of the curriculum to ensure students were engaged in the learning process as part of the typical curriculum. Open-ended instruction, lecture, experiential learning, peer evaluation, case studies, and project-based learning are used to reinforce the application and development of a wide range of technical writing challenges. Because engineers write for different purposes, audiences, and genres, it is important students have realistic experiences both in and out of the classroom that mirror the individual and team writing done in a practical setting. The importance of stylistically and grammatically correct documents that reflect the writer's knowledge, competence, and credibility is reinforced.

III. Theoretical Framework

Many different approaches have been attempted in introducing entrepreneurial education into engineering education [5] [6] [7] [8] [9]. The methods, purpose and scope of these courses vary. The thorough, literature-review based restructuring of a course is an ideal presented by [10], and represents one extreme of preparation based on ground-up course development. This study implements change in a way that disrupted the existing class as little as possible, and thus was more palatable for the active course instructors to integrate the changes. The treatment group received lectures and individual team consulting time only a few times during the semester. The team consulting visits were planned for days when teams had time to work together in class.

A. Methods of Instruction

Different methods of instruction have been promoted in various programs and studies for teaching entrepreneurship to engineering students. Mentorship by experienced entrepreneurs is often promoted for entrepreneurial education [11] [12] [6], as is peer interaction [12]. In [13], business students were recruited to give engineering students contact with entrepreneurial students and provide a peer mentoring type of experience. Peer review and peer reporting were used in [6]. Entrepreneurship case study is promoted for engineering students by [8] and [14]. Business plan development is promoted by [5] as an experiential approach that is founded on Bloom's taxonomy. Many plans [13] focus on experiential learning, while elements of problem-based learning and active and collaborative learning are also implemented [6].

The approach used in this study is similar to those just cited in its use of peer mentorship and peer assessment. However, the peer mentors are provided training as small-business consultants with an emphasis on helping local students develop successful startup businesses. Due to the culmination of the Technical Communication for Engineers course in a project proposal for both the treatment and control groups, the focus for the treatment group is to view their proposals through the lens of an entrepreneur. Class members thus receive entrepreneurial training as a class and feedback as project teams from student entrepreneurship consultants fulfilling the role of peer consultant-mentors. Ongoing training is provided to these student consultants by Dr. Michael Glauser on the Need, Experience, Resources, Customers, and Model (NERCM) principles found in [15]. The principles are based on his experience as a professional business consultant, the director of the Jeffrey D. Clark Center for Entrepreneurship, and the faculty advisor for Utah State University's Entrepreneurship Club and from his interviews and subsequent research of many successful entrepreneurs. The purpose of the principles is to help its users to identify real opportunities, rather than merely ideas.

Peer mentorship and peer assessment have been identified as effective methods of instruction. Peer instruction has been found to have many benefits, but the term generally applies more to cases where the instructors are members of the class, and the instruction is often centered on group discussions [16]. In this study, with the student consultants possessing their special entrepreneurial training and coming from outside the class population, peer mentorship is practiced as student consultants meet with class members. Cross-level peer tutoring where a student instructs others on something for which they have more experience may be a better label for when lectures are delivered per [16]. However, since peer mentorship is not always strictly defined and can cover many scenarios where students (generally more senior and experienced) serve to help other students, that term will be used for the general approach found in this study. Peer mentorship has shown benefits in both academic and social support and encouraging academic and social involvement. Many of the benefits to a university come through the mentors involved in peer mentorship as the mentors gain more expertise. This increases the average education level of a university's students not to mention prestige, and become social contacts who promote the topics and growth about which they provide mentoring for the rest

of the student population [17] [18]. Peer mentorship is applied in this study so that students receiving the mentoring will have a better understanding of entrepreneurial principles and, if they are interested, will have an easier avenue for social involvement with other entrepreneurial resources on campus like the Entrepreneurship Club.

During meetings with the student entrepreneurship consultants, student project teams are also on the receiving end of added peer assessment. [19] indicate that there are logistical, pedagogical, affective, and metacognitive advantages to incorporating peer assessment in the classroom. For purposes of this study, these peer consultant-mentors provide formative assessments of the projects [20]. No feedback from the consultants is used in a summative sense for grading purposes, and the only impact on student grades is extra credit equal to a day's worth of participation points. The extra credit points are available to all students who participate in the study's activities (whether they elect to provide their data to the study or not), and are not tied to their performance in the activities. The use of formative assessment is intended to impact the development of metacognitive skills, and the intent is to iteratively apply peer feedback in order to improve the performance of the course's students [21].

IRB approval was received for this study. An important point in IRB approval was that the professor could not know which students elected to provide their data to the study, and thus student participation did not result in a biased impact on their grade.

B. Increasing Entrepreneurial Interest and Mindset

In reviewing the literature it appears that implemented or planned entrepreneurial interventions within engineering education have an implied goal of increasing entrepreneurial interest or intent within the engineering students. [8] specifically states an intent to "plant the seeds" to raise students' interest levels. In some articles, the motivation to pursue entrepreneurship is labeled as an entrepreneurial mindset, and increases in the intent to pursue entrepreneurial activities are measured [7] [6] [14]. It is hypothesized that one of the factors in an entrepreneurial mindset may be connected to possession of a growth mindset, as described in [3]. A growth mindset where individuals feel that talent and intelligence can increase with applied effort seems key for both budding entrepreneurs and students facing the rigors of engineering education.

C. Creativity (aka Innovation) in engineering entrepreneurship

A growth mindset would seemingly also promote the use of creativity and innovation, the latter being often used to refer to technical creativity, which are common themes in engineering entrepreneurship. Creativity is often only dealt with at the intuitive level, but [22] point out its importance in understanding design engineering and discuss reliable efforts made to quantitatively identify creativity in design. [23] identify via a quantitative analysis that while not all creative designs are good designs, "creativity is normally regarded as a significant aspect of an overall 'good' design." [24] suggests that the importance of creativity, an attribute which may actually make engineering problem-solving more difficult but will benefit the final design, "may be related to the need to make rapid explorations of problem and solution in tandem, in the co-evolution of problem and solution," in the field of engineering. The same may be said of entrepreneurship, and such an attitude is reflected in the instruction given to participants in this study as they were taught to recognize and refine opportunities versus merely ideas given the NERCM constructs. Creativity is a construct that is important for engineers and entrepreneurs, and it is worth understanding in light of experimental treatments. [7] and [14] both have the goal of promoting innovation. [9] states that creativity exercises help students build their creativity skills. Limited past experience has shown that a single semester may be sufficient time for students receiving different instructional treatments to experience significantly different levels of creative development [2].

IV. Methodology (Data Collection)

Random selection was used to assign each section of the course to the control (traditional class instruction) or treatment (including entrepreneurial peer-led lectures). Random assignment is conducted within bounds to maintain an even split between control and treatment for each instructor providing class contact, when possible (i.e. when an instructor teaches an even number of class sections).

A. Measuring Entrepreneurial Interest

Survey instruments have been developed by individual authors, academic institutions, and organizations like the Kern Entrepreneurial Engineering Network. Each instrument is designed with the purpose of measuring the entrepreneurial intent of engineering students [6] [14] [7] [8]. For this study, the varied questions assembled in [25] is used to conduct pre- and post-assessments of students' entrepreneurial intent and beliefs. The pre-assessment is performed in the first half of the semester before entrepreneurial instruction by the student entrepreneurship consultants commences for the treatment group - entrepreneurial instruction begins the 5th week. The post-assessment is completed during finals week. All students participating in the study are given the entrepreneurial interest survey in class. Additionally, a demographic survey asking for students' gender, field of study, concurrent coursework, and hobbies was given to every participant. The demographic survey is provided to students online, and they may complete it at their convenience during the semester.

B. Measuring Creativity

The quantitative representation of creativity has been going on for some time, and some trends have been identified, such as the decrease in creative thinking scores since 1990 as measured by the Torrance Test of Creative Thinking (TTCT) [26]. As used in [2], the Abbreviated Torrance Test for Adults (ATTA), a derivative of the TTCT, is used to measure elements of creativity. The ATTA gives a summative, population-referenced score for creativity and measures four constructs

representing perceived features subskills of an individual's creative ability: Fluency, Originality, Elaboration, and Flexibility [27], and was chosen due to its short duration, reliability and validity [28]. The ATTA is given in a pre- and post-assessment format in order to observe any increase that occurred over the course of the semester. Approximately one half of the participants are randomly assigned to take this instrument. The pre- and post-assessments are given in class on the same dates as the entrepreneurial interest survey.

C. Measuring Mindset

In order to quantify participants' mindset (growth vs fixed) [3], the online survey developed by Carol Dweck [29] is delivered in a pre- and post-assessment format. Students who are not randomly assigned to receive the ATTA instrument are given this survey. The pre- and post-assessments are given in class on the same dates as the entrepreneurial interest survey.

D. Participant Population

Students taking the course are in the sophomore or junior year of a bachelor's degree in civil engineering, computer engineering, computer science, electrical engineering, environmental engineering, or mechanical engineering.

V. Methodology (Data Analysis)

Lagged regression will be used to gain insight into the correlations linking entrepreneurial instruction to increases in entrepreneurial intent levels, creativity, and mindset. The data from the demographic survey will also be used to look for trends related to these topics as well. Multiple linear regression will be used to link and control for hobbies, other background and demographic factors, creativity, and mindset to entrepreneurial interest levels, and the changes therein. The ATTA, being somewhat subjectively graded, will be graded by multiple graders. Training will initially occur to promote inter-grader reliability, and following the training the scores will be averaged across the multiple graders. The statistical analysis will be investigated in two ways, quasi-experimental and experimental, in a search for understanding and insight. In the quasi-experimental approach, as typically used in educational research, each participant will be treated as a single data-point. In the experimental approach, as preferred by the statistics community, each delivery of the course will be treated as a data point so a semester where 4 sections of the course are taught will result in the collection of 4 data points. In the experimental approach, each section's quantitative measures will come from an averaging of the scores for that section's participants.

VI. Conclusion

Data collection is underway. From the data it will be determined which factors are correlated engineering students' ratings in entrepreneurial intent, creativity, and mindset. The approach will enable comparisons with existing literature. Ultimately, we hope to gain insight into the correlations that entrepreneurial consulting has on the entrepreneurial outlook of student participants and the characteristics that impact entrepreneurial intent.

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