Integrating entrepreneurship learning module in capstone senior project courses

Naga Korivi, Oregon Institute of Technology

Naga Korivi is an Associate Professor and Chair of the Electrical Engineering and Renewable Energy Department at the Oregon Institute of Technology. He is the Program Director of the Electronics Engineering Technology program at Oregon Institute of Technology. He also serves as Director of the Oregon Renewable Energy Center, a state-funded center of applied research. Dr. Korivi has extensive experience in curriculum development, student engagement initiatives, retention, and incorporating technology into classrooms. His recent efforts have included pioneering semiconductor education and experiential learning programs for high school, 2-year, and 4-year college students. He holds a Ph.D. degree in electrical engineering from Louisiana State University.

Maurice Gunderson, Oregon Institute of Technology

Maurice Gunderson is a venture capitalist, entrepreneur, corporate director, engineer, and a lifelong aviator. He is Managing Director Emeritus of AutoTech Ventures. Previously he was a founder of Nth Power, one of the first energy venture capital firms; and a Senior Partner at CMEA Capital, where he was the lead investor in NuScale Power, a developer of modular nuclear power plants. Mr. Gunderson has served on boards of over thirty private and public companies. Prior to his VC career, Mr. Gunderson, an engineer, developed aerospace and energy products and launched eleven companies. Currently he manages scholarships for young people pursuing aviation and engineering careers. He also serves as an Adjunct Instructor at Oregon Institute of Technology. Mr. Gunderson holds an MBA from Stanford University, and a BA (Mechanical Engineering) and an MS (Thermodynamics), both from Oregon State University. He is a National Association of Corporate Directors Leadership Fellow, a Registered Professional Engineer, and a Life Fellow of the American Society of Mechanical Engineers.

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Naga Korivi, Maurice Gunderson
Electrical Engineering & Renewable Energy Department
Oregon Institute of Technology, Wilsonville, OR 07070
E-mail: naga.korivi@oit.edu

Abstract

Incorporating entrepreneurship into undergraduate engineering programs prepares students with skills for industry innovation, future workforce needs, and their own business ventures. Every enterprise, whatever size, was once a startup; insights into entrepreneurship thus help employees understand the enterprise they work in. A key method to integrating entrepreneurship in engineering curricula is through experiential learning, such as in capstone project courses, which provide project-based learning. However, engineering programs with limited programmatic flexibility and resources may face challenges in integrating entrepreneurship content into their curricula while meeting accreditation requirements. Addressing this, we report our observations from integrating an entrepreneurship lecture module in the capstone senior project course at the Oregon Institute of Technology's Electrical Engineering and Renewable Energy Department. The lecture module covered entrepreneurship topics such as bringing products to the market, cost analysis, and included an interactive group discussion. The module's impact on student learning was evaluated through pre- and post-lecture assessment. Analysis indicated a positive impact on the students who reported gaining knowledge on entrepreneurship concepts. All the students incorporated a key entrepreneurship concept in their projects, with most demonstrating a high degree of proficiency in application. One senior project spun off into a start-up involving two students from the capstone course. This approach provides engineering programs a way to incorporate basic entrepreneurship into capstone courses without devoting considerable resources to the process.

Keywords: capstone, senior design, entrepreneurship

Introduction

Global economic and workforce trends have highlighted the need for engineering students with a broad skillset capable of navigating and succeeding in an environment where innovation and entrepreneurship are central to economic growth [1]. Consequently, there has been an increasing demand for curriculum and educational programs that focus on innovation and entrepreneurship, tailored to engineering students. These educational opportunities are provided either by integrating entrepreneurship concepts into the engineering curriculum or through non-

engineering courses, minors, and certificate programs available to engineering students [2]. However, despite the growing recognition of the importance of entrepreneurship education for engineering graduates, research indicates that its widespread inclusion in undergraduate engineering curricula is still limited and not yet fully institutionalized [2, 3]. This could be due to factors such as ABET accreditation requirements or constraints related to program flexibility and resources. ABET, Inc. is a recognized organization responsible for accreditation of around 4,773 programs at 930 colleges and universities in 42 countries [4]. ABET accredits hundreds of engineering programs in the U.S. According to ABET, its criteria for accrediting engineering programs are intended to foster the systematic pursuit of improvement in the quality of engineering education. Among its various criteria for accrediting engineering programs, ABET requires that the curriculum includes a minimum of 30 semester credit hours of college-level mathematics and basic sciences appropriate to the program, and a minimum of 45 semester credit hours of engineering topics [5]. The average total credits for an engineering bachelor's degree is typically around 120 semester credits. Out of these, 75 semester credits are dedicated to engineering topics, math and sciences to meet ABET criteria. This means that engineering programs have limited programmatic flexibility to incorporate non-engineering courses on business and entrepreneurship.

It has been found that entrepreneurship is taught most effectively through experiential methods [6]. Considering that capstone design project courses are applied and experiential by nature, they provide an optimal platform for integrating entrepreneurship into engineering curricula [7]. Several approaches have been examined to integrate entrepreneurial content or curriculum into capstone project curriculum. In one approach, an entrepreneurship minor was developed at Lehigh University consisting of five courses, including two final project courses [8]. In another approach, an engineering entrepreneurship program was implemented at North Carolina State University [9]. The program consisted of weekly seminars on business topics with some participants going through a multiple-semester experience. While these approaches may provide comprehensive entrepreneurship exposure to students, they might not be feasible for programs with limited resources.

There is a need to explore methods to incorporate entrepreneurship content into capstone courses without modifying curriculum significantly and expending minimal resources. In this paper, we report our observations from integrating an entrepreneurship lecture module in the capstone senior project course at the Oregon Institute of Technology's Electrical Engineering and Renewable Energy Department. The module covers entrepreneurship topics such as bringing products and innovations to the market and includes an interactive group discussion. This is a work in progress. The key goal of this paper is to evaluate the impact of the entrepreneurship lecture module deployed in capstone course. The initiative does not involve any significant changes to the program curriculum.

Methodology

A one-hour interactive entrepreneurship lecture module was integrated in a capstone senior project course (ENGR 465) in Spring 2024 at the Electrical Engineering and Renewable Energy (EERE) Department at Oregon Institute of Technology’s Portland-Metro campus. This course is

taken by all senior undergraduate students enrolled in three programs offered by the department, namely – electrical engineering, electronics engineering technology, and renewable energy engineering.

As with every engineering school, OIT's undergraduate engineering programs are necessarily and appropriately focused and demanding, leaving little time for students to explore divergent facets of their future careers. While success in engineering school is mostly measured in engineering terms (via problems sets and exams), the majority of OIT's students pursue careers in for-profit companies in which success is measured in financial terms. The one-hour entrepreneurship lecture was structured to give a view of typical magnitude of engineering cost and time relative to other key business functions, such as finance, marketing, sales, production, etc. The start-up company model was used for two reasons. First, because start-ups are simpler than mature companies, and thus lend themselves to a focused discussion; and second, because every company, no matter how large or long established, was once a start-up, and often can be analyzed in start-up terms.

The lecture was conducted in-person by an expert venture capitalist (incidentally, whose first career was in aerospace engineering) with more than 30 years of experience in the field of venture capital and with a portfolio of founding at least five companies, and funding about a hundred companies. The lecture was followed by a question-and-answer session which included capstone students describing their projects to the venture capital expert and seeking feedback. The entire experience lasted three hours.

The lecture covered key entrepreneurship topics including:

- Preparing a business proposal
- Costs analysis – Estimating relative cost of a new product through its lifecycle
- Getting a venture capitalist to review a proposal
- What venture capitalists look for in a successful proposal

The module's impact on student learning was evaluated before and after the entrepreneurship lecture. The pre-lecture assessment was quantitative and done through a survey asking students about their prior exposure to entrepreneurship concepts and to gauge their interest in learning about entrepreneurship (Table 1).

Table 1: Pre-lecture assessment.

Quantitative	
Survey question	**Response options**
Do you have prior exposure to entrepreneurship concepts?	Yes
	No
Would you be interested in learning about entrepreneurship?	Yes
	No

The post-lecture assessment involved quantitative and qualitative methods. Quantitative assessment was based on a survey asking students if the lecture increased their knowledge on

entrepreneurship and how useful they felt the lecture was (Table 2). The survey also asked students whether they thought they would benefit from having similar lectures in other courses in their curriculum. The qualitative assessment was based on a one-question survey asking students about the specific parts of the entrepreneurship lecture they found most useful. Another part of the qualitative assessment evaluated student performance in a course assignment on applying a key entrepreneurship concept (cost analysis) to their own capstone projects. Students were asked to submit a report with a cost analysis for the products they were developing through the capstone. The course instructor provided guidance and additional support to the students as needed. A rubric was employed to assess student performance on the cost analysis assignment, as shown in Table 3.

Table 2: Post-lecture assessment.

Quantitative	
Survey question	**Response options**
Did the entrepreneurship lecture increase your knowledge on the topic?	Yes
	No
What is your overall feeling about the entrepreneurship guest lecture?	Not useful
	Useful
	Very useful
If there were similar guest lectures in other EERE courses throughout your degree program, would that have improved you as a student and prepared you better for professional life?	Yes
	No
	Maybe
Qualitative	
Survey question	
Which part of the guest lecture was most useful or beneficial to you?	
Course assignment	
Perform cost analysis for the project	

Table 3: Rubric to evaluate student assignment on cost analysis.

Rubric to evaluate the cost analysis assignment	
Criteria	**Evaluation ratings**
• The analysis is methodical and considers all relevant aspects of the project. • Detailed description of cost breakdown and relevant explanations are provided. • Realistic constraints and assumptions are applied where needed. Assumptions are clearly stated and justified. • All calculations are accurate, well-organized, and explained with clear justification for estimates and choices.	• **High proficiency:** All the criteria are met; little to no improvement is needed. • **Proficiency:** Most of the criteria are met; room for minor improvements. • **Some proficiency:** Multiple criteria are not met; needs moderate improvement in multiple requirements. • **Limited proficiency:** Most of the criteria are not met; needs substantial improvement in most requirements.

Results & discussion

Pre-lecture survey responses were collected and analyzed. As shown in Table 4, all (100%, n = 9) the surveyed students indicated that (a) they did not have prior exposure to entrepreneurship; (b) they wanted to learn more about entrepreneurship. This is consistent with previous studies at other universities, where engineering students showed interest in learning more about entrepreneurship, yet only a small number reported exposure to it, even at universities with formal entrepreneurship programs [3].

Table 4: Pre-lecture survey results.

Quantitative survey (n = 9)		
Question	**Responses**	
Do you have prior exposure to entrepreneurship concepts?	Yes	0%
	No	100%
Would you be interested in learning more about entrepreneurship?	Yes	100%
	No	0%

Results from quantitative post-lecture surveys (Table 5) showed that all (100%, n = 9) the student respondents in the capstone course indicated an improvement in their knowledge level in entrepreneurship. Further, 100% of the respondents found the entrepreneurship lecture to be useful/very useful. Comparing this feedback to that obtained through the pre-lecture survey, it is apparent that the students feel they gained knowledge from the entrepreneurship lecture module.

Table 5: Post-lecture survey results.

Quantitative (n = 9)		
Survey question	**Responses**	
Did the entrepreneurship lecture increase your knowledge on the topic?	Yes	100%
	No	0%
What is your overall feeling about the entrepreneurship guest lecture?	Very useful	55%
	Useful	45%
	Not useful	0%

The quantitative post-lecture survey data aligns well with qualitative assessment done through a course assignment. In the assignment, students were asked to conduct cost analysis for their product being developed in their project. Student performance in the course assignment was evaluated using the rubric shown in Table 3 and the resulting data is shown in Figure 1. About 50% of the students demonstrated “High proficiency”, and 20% demonstrated “Proficiency”. In this study, an evaluation rating of “Proficiency” and better was considered the desired goal. Since the majority (70%) of the students met this threshold, we infer that the students gained knowledge on cost analysis from the entrepreneurship lecture and were able to apply it to their projects. This is consistent with prior observations by others who reported that students who

were exposed to some entrepreneurship curriculum were much more likely to get hands-on skills related to entrepreneurship concepts such as market analysis, commercialization of technology, business communication, among others [3].

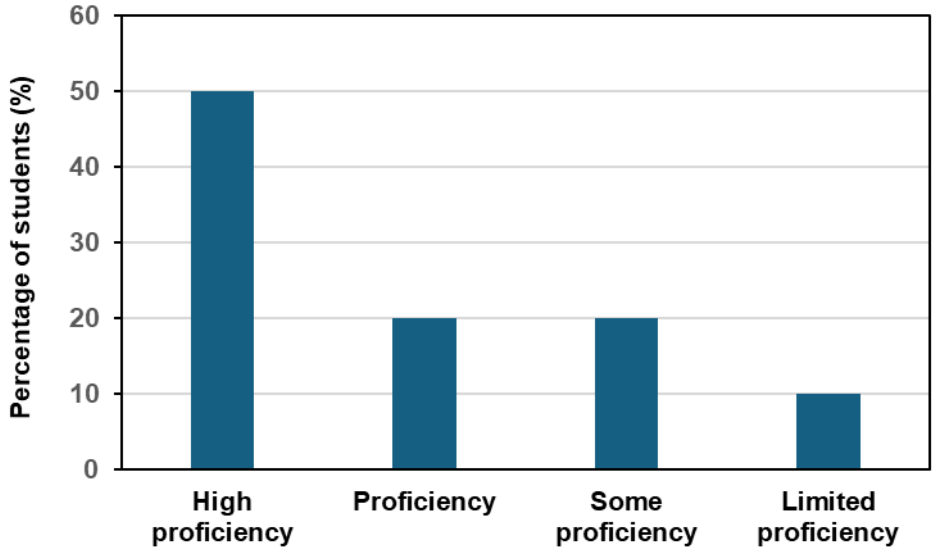

Figure 1: Evaluation of student assignment on cost analysis.

As part of the post-lecture assessment, qualitative feedback was sought from the students on which part of the lecture module was most useful to them. The responses were compiled and reviewed (Table 6). Among specific topics, the cost estimation of bringing a product to the market was mentioned by 3 out of 9 student respondents. The feedback generally indicated that the students received the lecture module positively and found the experience inspiring/encouraging. This was consistent with the instructor's observations of interactions between students and the venture capitalist during the entire three-hour entrepreneurship interaction. In subsequent regularly scheduled meetings for the capstone course, the instructor allocated time for student-led follow-up discussions on entrepreneurship. Students also discussed ways to collaborate on potential business plans. One senior project spun off into a start-up involving two students from the capstone course.

Table 6: Post-lecture qualitative assessment

Student	Feedback
#1	It was very informing to understand the importance of how much money, time, and effort is required to get an idea to market or even to have a venture capitalist take a look at a proposal. Hearing about the business side of novel proposals is very important for future engineers who will likely be involved in creating something new that can potentially go to market. This is very relevant to the Capstone project.

#2	Even though I have no plans to start or enter the entrepreneurial space, having understanding of the approach and methods was very informative. The opportunity to speak with the quest speaker in a one-on-one fashion was amazing. Having the opportunity to ask questions afterward and have a conversation with the quest was the best part for me.
#3	The advice on the relative costs of a new product throughout its lifecycle (the Pi model) was most helpful to me, and I believe it is critical information for all EE/RE graduates, as many start their own businesses.
#4	I do not have much interest in starting my own company, but I do see myself as potentially working for a startup, so it was helpful to hear what venture capitalists want to see in a company.
#5	I enjoyed hearing from someone with such a unique perspective and experience. The discussion around the FE exam was particularly helpful, as that was something I was thinking about taking. I'm not planning to run a business (at least in the near term) so some of the information was not directly relatable at this time but I can see how it would be useful for others in the group.
#6	It was highly informative to receive insights from someone experienced in the field. There were several valuable lessons, including the basics of venture capital, how to make job decisions, and planning for business development costs.
#7	I thought the whole presentation he gave was beneficial.
#8	I found that their insights on solar energy were quite useful for research ideas for my current capstone project.
#9	The entrepreneur’s experiences provide valuable knowledge for students considering a similar path. Additionally, their stories serve as motivation and guide aspiring entrepreneurs on their journey.

Based on the overall quantitative and qualitative results, we judge the interactive entrepreneurship lecture module to have been a success from an instructional point of view. We plan to improve and expand this offering in the future. Of course, the most important opinions will come in a few years from our graduates. We look forward to learning if this module was of help in their early careers. Perhaps some will have been inspired to pursue some business education.

Conclusions

In this work in progress, an entrepreneurship lecture module was integrated into a capstone senior project course. Pre- and post-lecture assessment was done through qualitative and quantitative methods. Analysis of the assessment data showed a positive impact on the enrolled students who reported an increase in their knowledge on entrepreneurship topics. The observations show the feasibility of a lecture module to improve student knowledge of entrepreneurship. The findings of this study offer important baseline data that can be valuable for entrepreneurship/capstone program development and related assessment.

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