Impact of Integrated E-Learning Modules in Developing an Entrepreneurial Mindset based on Deployment at 25 Institutions

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Impact of Integrated e-Learning Modules in Developing an Entrepreneurial Mindset based on Deployment at 25 Institutions

Abstract

In this paper, we describe an innovative curricular model employed at the University of New Haven to develop an entrepreneurial mindset in engineering students. The entrepreneurial mindset in this model is characterized by the Kern Entrepreneurial Engineering Network (KEEN)'s 3C's, which are *curiosity*, *connections* and *creating value*. The core of the model is the integration of short, self-paced, e-learning modules into courses spanning all four years of all engineering and computer science programs. A flipped classroom instructional model is used to integrate the modules into courses. We are in the third year of implementation on campus, and following a pilot deployment of the model at five other institutions in spring 2016, have conducted a large-scale deployment. Six e-learning modules were deployed at 25 institutions across the country during the 2016-17 academic year.

We first summarize the integrated e-learning model implemented at the University of New Haven, which follows a clearly defined structure on module and course mappings. This structure, however, is not rigid, and we demonstrate by examples the wide potential for adopting these modules within all engineering disciplines and at all class levels. We also describe the deployment and adoption of these modules at 24 other institutions. We assessed the impact of the modules on student learning using pre and post surveys, and student and instructor feedback. We performed assessment across all institutions where modules were deployed. We also discuss lessons learned during development, and internal and external deployment of the e-learning modules.

Introduction

More and more higher education institutions are trying to develop an entrepreneurial mindset in students. Approaches for doing this include integrating entrepreneurship into the curriculum, structuring the physical environment to promote entrepreneurial minded learning (e.g., creating makerspaces), providing extracurricular activities and programs such as university innovation fellows, business plan and pitch competitions, and fostering student organizations that lead entrepreneurial activities on campus. The most common methods in embedding entrepreneurship education within the curriculum are offering a foundational course on entrepreneurship and/or offering a minor in entrepreneurship. Business schools commonly offer the courses on entrepreneurship.

Business schools and business education has been around since the latter half of the 19^{th} century. Khurana provides a historical account of business education in the US, indicating that much of its development was driven by market need.[1] Nino cites *Institutional Factors*, including limited practical training of faculty, as one of the main challenges facing business education due to the ever-changing demands of the economic market.[2] Rauch and Hulsink credit much of the rise in employment and economic growth seen in the past decades to be driven by *entrepreneurship*.[3] Lumsdaine and Binks explained that the primary mode of training of engineers in business practices and entrepreneurship had been for graduates to pursue an MBA.[4] During the past two decades, courses and programs in entrepreneurship education have been established and propagated throughout colleges and universities.[5-7] The 2008 report by the Kauffman Foundation concluded that "the diversity of institutional types and educational missions of American colleges and universities make a single approach to entrepreneurship both unrealistic and inauthentic".[6] Yet, many argue that agreement of what and how entrepreneurship education should be carried out is still lacking.[7-10]

Specific to engineering programs, Gandhi *et al.* estimate that nearly two-thirds of engineering schools rely on course offerings by their business schools to address innovation and entrepreneurship.[11] Their research showed that of the top 50 universities in the US, 42 offer entrepreneurship courses through the business school, whereas only 18 offer the courses directly through the engineering school. The authors claim that "courses in innovation and entrepreneurship taken by the engineering students (through the business programs) do not necessarily focus on the goal of promoting innovation and entrepreneurship within the engineering domain," and call for further research into the difference between the offerings. Students who take business and entrepreneurship courses often self-select and the courses often have to be counted as electives in their respective programs. In an effort to more broadly expose engineering students to entrepreneurial skills and topics, some programs aim to embed the topic within the engineering curriculum via case studies,[12] capstone projects,[13-16] or modules.[17,18]

In the Tagliatela College of Engineering at the University of New Haven we employ an innovative curricular model to develop an entrepreneurial mindset in students that is based on integrating short e-learning modules into existing engineering courses.[19, 20] There have been many studies about the effectiveness of e-learning, and some still question it.[21] However, examples of e-learning, such as fully online engineering graduate programs[22] and MOOC offerings,[23] are increasing as computer technology advances. Furthermore, the literature supports that e-learning is effective in achieving student learning outcomes.[24-26]

We are in the third year of implementing this curriculum model at our campus. In spring 2016, we launched a pilot program to deploy these e-learning modules in engineering courses at other institutions to assess their effectiveness in developing an entrepreneurial mindset in engineering students. Six e-learning modules were deployed at 25 institutions across the country during the 2016-17 academic year. We report findings based on data collected from the fall 2016 deployment.

Background

At the University of New Haven we employ an innovative curricular model to develop an entrepreneurial mindset in engineering students. We characterize the entrepreneurial mindset based on the Kern Entrepreneurial Engineering Network (KEEN)'s 3C's, which are *curiosity*, *connections* and *creating value*. The learning outcomes and complementary skills in the KEEN framework that we attempt to achieve through the e-learning modules are shown in Table 1. The contextual activities, explained in the following section, provide the reinforcing method to help students gain the complementary skills.

Table 1 Entrepreneurially Minded Learning (EML) Outcomes and Skills

EML Outcomes	
Dimension	**Learning Outcome**
CURIOSITY	Demonstrate constant curiosity about our changing world
	Explore a contrarian view of accepted solution
CONNECTIONS	Integrate information from many sources to gain insight
	Assess and manage risk
CREATING VALUE	Identify unexpected opportunities to create extraordinary value
	Persist through and learn from failure

EML Complementary Skills	
Dimension	**Learning Outcome**
OPPORTUNTIY	Identify an opportunity
	Investigate the market
	Create a preliminary business model
	Evaluate technical feasibility, customer value, societal benefits, economic viability
	Test concepts quickly via customer engagement
	Assess policy and regulatory issues
IMPACT	Communicate an engineering solution in economic terms
	Communicate an engineering solution in terms of societal benefits
	Validate market interest
	Develop partnerships and build a team
	Identify supply chains distribution methods
	Protect intellectual property

Integrating the e-learning modules into courses consists of four components: (1) Using a flipped classroom model, students complete the e-learning module outside of class over a two-week period; (2) During the second week, instructors engage students with the content through an online or in-class discussion; (3) After completing the module, students work on a class project or activity that reinforces content and/or skills learned in the module; and (4) Assessment of student learning from the e-learning module is conducted using pre- and post module survey results, student performance on the contextual activity and/or final exam questions.

The 18 e-learning modules being developed by the University of New Haven are listed in www.newhaven.edu/keen. We have developed and deployed ten of these modules at the university, and six have also been deployed widely at other colleges and universities. The learning outcomes of the completed modules are shown in Appendix 1. Content experts selected through a competitive process developed these modules. Faculty and working professionals from around the country responded to requests for proposals (RFPs) over the last two years for development of the modules. Developers chosen completed a one-week online training course during the summer to learn how to develop effective and interactive e-learning modules. The online training course was developed by the Office of eLearning at the University of New Haven. In addition, all developers viewed a webinar that familiarized them with entrepreneurial thinking and KEEN's goals. One person, or sometimes a group, was selected to develop each module, and worked with a course designer as well as a review team assembled by the university. The typical time to develop a module was 4-6 months, and 3-4 modules were developed simultaneously during each cycle. Once developed, the modules were integrated into engineering and computer science courses at the University of New Haven. Student and instructor feedback was solicited after each deployment, and modules were revised as necessary.

We conceived a mini-grant process for spring 2016. We presented the e-learning modules to all attendees at the KEEN Fall Meeting held at Villanova University from October 1-3, 2015, and conducted a brief workshop providing more detail on the modules for interested participants. We issued an RFP to deploy an e-learning module in an engineering course in mid October 2015 to all universities that were then part of the KEEN network. Based on the applications received, we awarded faculty at five institutions $2000 mini-grants to deploy five modules in their courses during spring 2016. The modules were exported from Blackboard and integrated into the Learning Management System (LMS) at the deploying institution. An IT staff member at the University of New Haven worked with an IT staff member at each of the deploying institutions to facilitate the export and import of the modules.

We held a virtual workshop that focused on strategies for deployment, including content transfer logistics and development of contextual activities, in December for external deployers. All deployers had proposed to use the modules in classes different than those that had been deployed at the University of New Haven. Each one of us (the authors) was assigned the responsibility for one module and coordinated with the faculty deploying that module. Pre and post surveys designed for each module were completed by students before and after learning from the modules and contextual activities carried out by instructors in their courses. We collected feedback from instructors, course syllabi and assignments used for the contextual activities at the end of the semester. The pilot offering allowed export/import problems to be worked out, and we also revised questions on the pre/post surveys based on student responses.

Deployment in Fall 2016

Following reasonably successful deployment at the five KEEN partner institutions in spring 2016, we planned a large-scale deployment for academic year 2016-17. We distributed an RFP to lead faculty at KEEN institutions, deans of engineering colleges who attended the 2016 Engineering Deans Institute, and other targeted faculty. We asked administrators to forward the RFP to interested faculty in their institutions. Through this process, we received 55 applications from faculty at 28 institutions around the country, including the University of New Haven. Based on the budget allocated for the mini-grant program, we awarded 29 faculty from 25 institutions a mini-grant of $2000 to deploy one of seven e-learning modules in a course they taught. Of these, 16 institutions deployed in fall 2016, and the remaining 8 deployed in winter/spring 2017.

All selected faculty were required to attend a half-day training workshop that we conducted on June 25, 2016 in New Orleans, LA, prior to the 2016 ASEE Annual Conference. We provided the participants an overview of the KEEN goals and objectives, the e-learning modules, and the approach for integrating them into courses. Faculty then worked in groups to discuss how contextual activities could be developed for their courses, and came up with preliminary ideas.

An IT staff member at the University of New Haven exported each e-learning module from Blackboard into a common course cartridge. He created instructions on how the common course cartridge could be imported into the various LMS's used by deployers, which included Canvas, Desire2Learn, iLearn, Moodle and Sakai. He provided assistance to IT staff and faculty members at deployer institutions as needed. Most imports worked well, with Moodle being the most problematic. Because Moodle is often customized by each institution, the modules often did not import cleanly and some of the interactive functionality was lost.

Given the scale of the deployment in fall 2016, we hired a part-time coordinator to work with each faculty member who deployed a module. She communicated frequently with each faculty member to ensure that the pre and post surveys were administered, and collected the feedback from instructors, course syllabi and assignments used for the contextual activities. Table 2 shows the courses in which each of the modules were deployed at the 16 external institutions during fall 2016. Appendix 2 provides a complete list for the spring 2015, fall 2016 and spring 2017 deployments.

Table 2 Fall 2016 Courses in which Modules were Deployed

The elevator pitch: advocating for your good ideas	**Applying systems thinking to solve complex problems**
MECH 1208: Intro to Mechanical Engineering II STS 1500: Sci, Tech. and Contemporary Issues ENGR 425: Reinforce Concrete Structures EECE 5001/5031, 5002/5032, EE/CompE Senior Design	ME 391: Independent Study: Robotics and Mechatronics MECH 432: Energy Systems (Sustainability Course) ChE 4131: Process Design I ECCS 4731: Capstone Seminar
Thinking creatively to drive innovation	**Learning from Failure**
ME 3295/MSE 4095: Introduction to 3D Printing: Learn by Building ENGR 498: Innovation	EGR 101: Intro to Engineering CE 336: Soil Mechanics ECCS 4731: Senior Design 2
Cost of production and market conditions	**Building, sustaining and leading effective teams and establishing performance goals**
ME 3421: Manufacturing Processes EE 485/585: Engineering Operations	CIVL 409: Concrete Design

Assessment

We conducted two types of assessment to evaluate the impact of the e-learning modules on behavior/mindset growth related to entrepreneurial thinking and on the perceived benefits gained from integrating the modules into engineering classes. We assessed acquisition of knowledge related to entrepreneurial thinking concepts through module specific pre and post surveys. The pre survey was administered at the beginning of the course before the students were exposed to the module and related activities. The results of these pre surveys provided a pre-exposure benchmark on student awareness of the entrepreneurial characteristics that the e-learning modules intended to develop. The same module-specific survey was then administered at the end of the course and we compared the results to the pre-exposure benchmark to determine student learning. We assessed the impact of deploying the e-learning modules in engineering courses and students' views regarding them by collecting instructor and student feedback. We will use the assessment results to improve the content and integration of the e-learning modules. As previously discussed, 16 external deployments of six modules were completed in fall 2016. The results of the module specific surveys and instructor and student feedback from the 16 external deployments of six modules completed in fall 2016 are presented below.

Pre and Post Module Specific Surveys
There were 42 questions (6-8 in each survey), with each question having either a *True* or *False* answer. Students were asked to select one of the following three choices for each question: "I don't understand the question", "I understand the question but I don't know the answer", or "True/False". For the third response, students were asked to choose either *True* or *False*. The "I understand the question, but I don't know the answer" choice was included to reduce guessed responses that might distort the data. The "I don't understand the question" response was included to evaluate the clarity of survey questions from students' perspective and to further reduce the distortion of data with guessed responses. Table 3 shows the aggregate data for all questions in each survey and the results show improvement in each category for every module except for the "I don't understand the question" category in the *Thinking Creatively* module. Therefore, in a broad sense the results imply that the e-learning modules are effective in helping students improve their knowledge of entrepreneurial thinking concepts.

Table 3 Overall Average Responses for Each Response Category

	Response					
	Correct Response		I understand the question, but don't know the answer		I don't understand the question	
Module	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Systems Thinking	62.9%	66.1%	13.2%	7.1%	2.3%	1.1%
Cost of Production	53.1%	65.1%	14.4%	2.7%	3.6%	2.7%
Elevator Pitch	58.6%	65.8%	10.0%	3.5%	1.8%	0.3%
Learning from	70.1%	79.1%	12.6%	3.8%	1.0%	0.0%
Thinking Creatively	75.3%	89.1%	9.0%	3.8%	0.3%	1.1%
Effective Teams	57.9%	57.9%	6.0%	4.4%	2.4%	1.6%

Improvement in the correct response and the "I understand the question, but I don't know the answer" response indicate that students form relevant knowledge on the module topic. 37 out of 42 survey questions had improvements, 3 stayed at the same level, and the response for 2 questions deteriorated (i.e., the number of students selecting the "I understand the question, but I don't know the answer" response for these 2 questions increased). Out of the 37 questions that showed improvement, students selected the correct response for 31.

Further analysis of questions that did not show improvement or had responses trend in the undesirable direction, indicated that none of the questions were of concern in terms of the modules' effectiveness on imparting knowledge related to entrepreneurial thinking. This is because, as shown in Table 4, for all these questions, students' selection of the correct response either increased or stayed at the same level as before. Furthermore, except for one question, students' selection of incorrect responses decreased. The increase in "I understand the question, but don't know the answer" statement for two of the questions may imply that some students became more familiar with the concepts after completing the modules, but did not learn the correct answers.

The only point of concern in the data for the "I understand the question, but I don't know the answer" statement was that three out of the five questions that did not show improvement were all from the same *Effective Teams* module survey. It appears that the survey questions for the *Effective Teams* module need to be revised.

Table 4 Statistics for Questions that Did Not Show Improvement in Forming Relevant Knowledge

Question	Response							
	I understand the question, but don't know the answer		Correct Response		I don't understand the question		Incorrect Response	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
1 CT: Q4	16.0%	17.4%	30.0%	56.5%	0.0%	4.3%	54.0%	21.7%
2 ET: Q5	5.6%	8.3%	66.7%	66.7%	0.0%	0.0%	27.8%	25.0%
3 ET: Q6	2.8%	2.8%	66.7%	72.2%	2.8%	2.8%	27.8%	22.2%
4 ST: Q4	3.4%	3.4%	89.2%	95.5%	2.5%	0.0%	4.9%	1.1%
5 ET: Q3	8.3%	8.3%	69.4%	69.4%	5.6%	2.8%	16.7%	19.4%

The third metric studied to evaluate the effectiveness of the modules was the number of correct responses. Out of 42 survey questions, 33 showed improvement in the percentage of correct responses with improvements ranging from 2% to 27%. In the remaining 9 questions, while the number of correct response did not change between the pre and post surveys for 3 of the questions, 6 questions showed a decrease in the number of correct responses. Further investigation into these questions revealed that four of them were not of concern since responses were scattered among the different surveys. However, the other 5 questions did pose a serious concern since they were all from the *Effective Teams* module. The survey questions for this module had already been identified as being problematic. The average percent improvements for each module are shown in Figure 1 and the aggregate data showed no improvement for the *Effective Teams* module, which further strengthens concerns about the survey questions for this module.

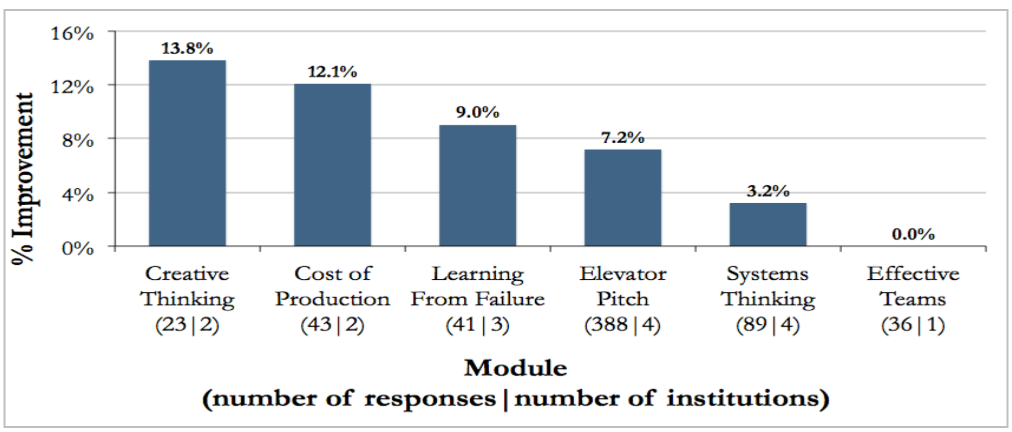

Figure 1 Average Percent Improvement After Integrating e-Learning Module

Instructor Feedback

We used a web-based form to collect instructor feedback on the impact of the e-learning modules and the effectiveness of the deployment process. The complete instructor feedback form is provided in Appendix 3.

The responses showed that all of the EML outcomes in the KEEN framework are collectively covered by the e-learning modules, but not by any one module; a result that was expected. As discussed in section 2, it is the complete set of 18 modules that collectively aim to cover all EML outcomes and complementary skills.

The responses about the EML outcomes were relatively consistent across the faculty who deployed each module. Table 5 shows the EML outcomes identified by faculty for each module. The only module that raised a concern was again the *Effective Teams* module, because the single instructor who deployed this module did not think that this module covered any of the EML outcomes. This is not particularly surprising because the module was intended to address one of the EML complementary skills (i.e., develop partnerships and build a team).

Table 5 EML Outcomes Covered by Each Module

	Module/ # Deployed					
EML Outcome	Elevator Pitch (4)	Thinking Creatively (2)	Systems Thinking (4)	Learning from Failure (3)	Cost of Prod. (2)	Effective Teams (1)
Demonstrate constant curiosity about our changing world		*2*				
Explore a contrarian view of accepted solution	4	1	2	2		
Integrate information from many sources to gain insight	4	1	4			
Assess and manage risk	1			3		
Identify unexpected opportunities to create extraordinary value	4	1	4		2	
Persist through and learn from failure	3			2		

The EML complementary skills to be developed by the contextual activities included all skills listed in Table 1 except for identifying supply chain distribution methods. For example:

- The contextual activities for the *Elevator Pitch* module consisted of having students give elevator pitches as part of their lab or project work. In an introductory mechanical engineering class, a newly designed tool (wrench, hammer, etc.) that was different than any other product in the market was pitched to buyers from major hardware stores. In a senior level civil engineering course, students pitched the design of a two-story parking garage that was technically feasible, economically viable, and benefited society. In a senior level electrical and computer engineering design class, students pitched their project proposals. In an introductory science and technology course, students pitched their innovation ideas for their preliminary patent application. These activities targeted: opportunity identification; market investigation and interest validation; technical feasibility; customer value; evaluating societal benefits and economic viability; and communicating engineering solutions in terms of both economic and societal benefits.
- The deployment of the *Systems Thinking* module was done at the junior or senior levels in electrical, mechanical, industrial and chemical engineering classes, and activities included designing an HVAC system, designing a production system, improving a chemical process, and improving the ordering process at a university cafeteria using the concepts introduced in the *Systems Thinking* module. The targeted skills were: identifying opportunity; evaluating technical feasibility; customer value; societal benefits and economic viability; communicating engineering solutions in economic terms; and developing partnerships and building a team.

These and other examples provided through the instructor feedback forms showed that the instructors were able to integrate the material covered in the modules into their classes through various activities, and were able to help students gain one or more of the complementary skills included in the KEEN framework. Furthermore, the variety of engineering disciplines and class levels in which these modules were deployed, as well as the variety in the type of contextual activities associated with the modules, demonstrate the flexibility and wide potential for adopting these modules within engineering programs.

Although the modules were not designated for any specific class level, most were integrated into similar level classes as shown in Table 2. The majority of faculty (75%) found the module content to be suitable for their classes, while some (25%) considered the module content to be easy or very easy for their class. In terms of student learning, the faculty found the modules effective largely by providing students content to help them make connections to real life experiences. The faculty also observed that the modules and contextual activities engaged students in conversations about the topic. Despite specifying enhancement in student learning, the faculty also reported some challenges that the students experienced. 6.25% of the faculty indicated that students had difficulty in connecting the module content to the course; 18.75% of the faculty observed that students found completing the module and related activities a burden.

We asked the faculty to rate how useful they found the e-learning modules with respect to the following five objectives aimed at developing an entrepreneurial mindset in engineering students:

- Provide material that leads to student learning
- Enhance student learning in the context of their class
- Trigger student curiosity into new areas
- Expand the boundaries of traditional classroom-based learning
- Enrich course content without giving up time for other topics

The rating was on a five-point Likert scale (with 5=very useful, and 1=not useful at all). The results, shown in Figure 2, clearly indicate the benefits of implementing these modules in engineering courses. For all objectives, the faculty rated these modules above 4.

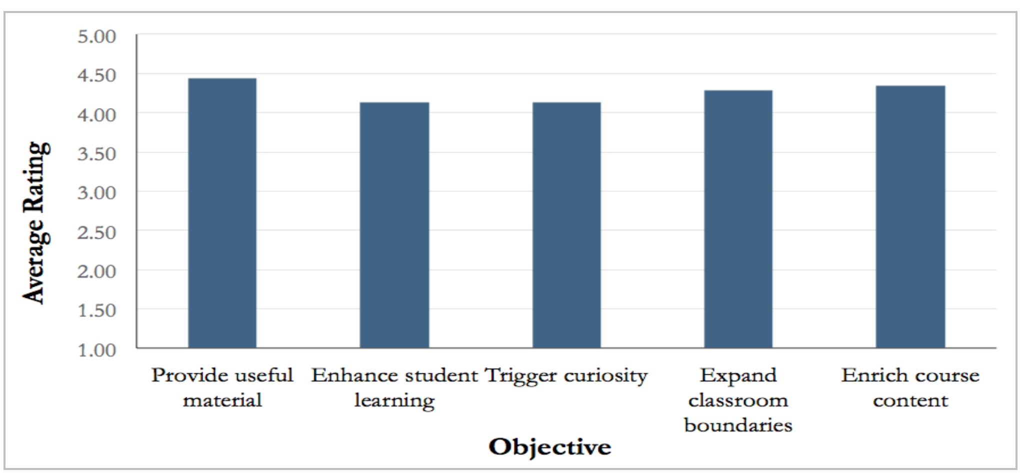

Figure 2 Faculty Rating of the Benefits of the e-Learning Modules

We asked the faculty to provide an overall rating on the e-learning modules using a five-point Likert scale (with 5=excellent, and 1=poor) and the results were very encouraging. Figure 3 shows the average rating for four user experience statements in a stacked bar (cumulative) format for each of the modules. Also shown is the average rating for all faculty and modules. All of the e-learning modules, with the exception of *Cost of Production*, were well-received in terms of value and course enhancement, and the faculty indicated that they are likely to adopt other modules and recommend the ones they deployed to others. Though the *Effective Teams* module raised concerns based on faculty feedback, its ratings were comparable to other modules in terms of user (deployer) experience.

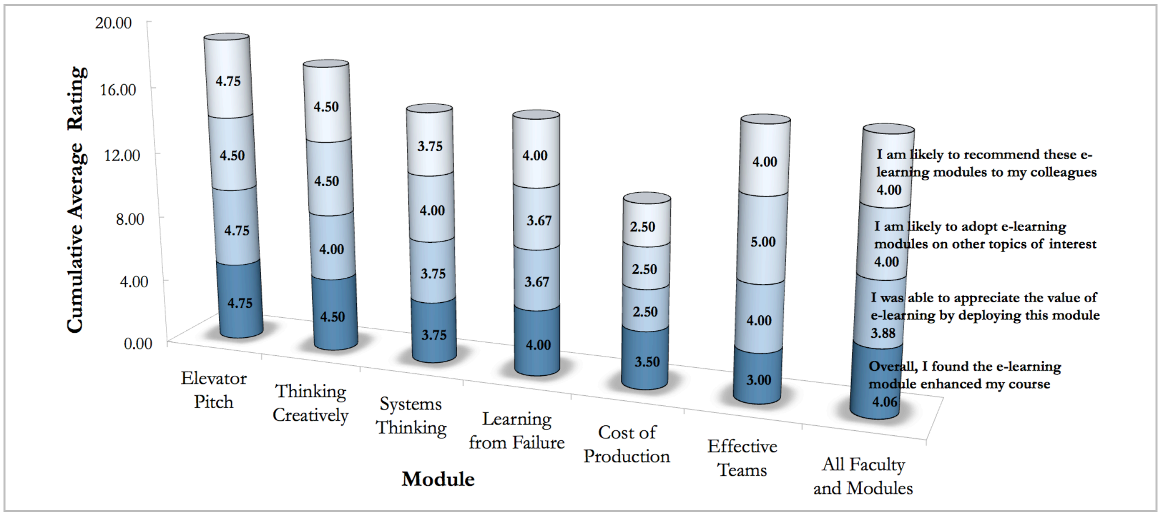

Figure 3 User Experience for Modules

Finally, the overall rating for each module as well as the average rating for all faculty and modules, shown in Figure 4, indicate that almost all faculty had a very positive experience in implementing the e-learning modules. However, additional deployments are needed in order to have a reliable estimate for each module individually, since the current sample size is too small (ranging from 1 to 4). The two modules, *Effective Teams* and *Cost of Production*, for which the assessment results raised potential concerns, were the two that received the lowest rating for the overall implementation experience.

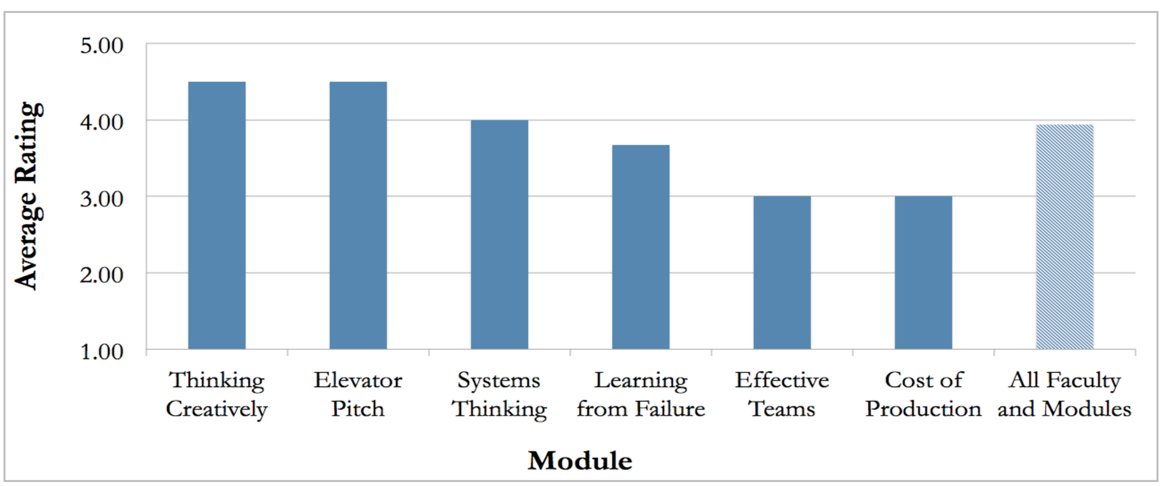

Figure 4 Overall Implementation Experience

Student Feedback
As discussed in section 3, the contextual activity is very important in helping students apply the knowledge learned from the e-learning modules. Student feedback was sought to evaluate the deployment process followed, especially with respect to the use and effectiveness of the contextual activity. Students were also asked about the perceived value of the e-learning modules and their attitude toward having modules deployed in more classes. The rating was on a five-point Likert scale (with 5=strongly agree, and 1=strongly disagree). Figure 5 shows average student responses by module and the overall averages.

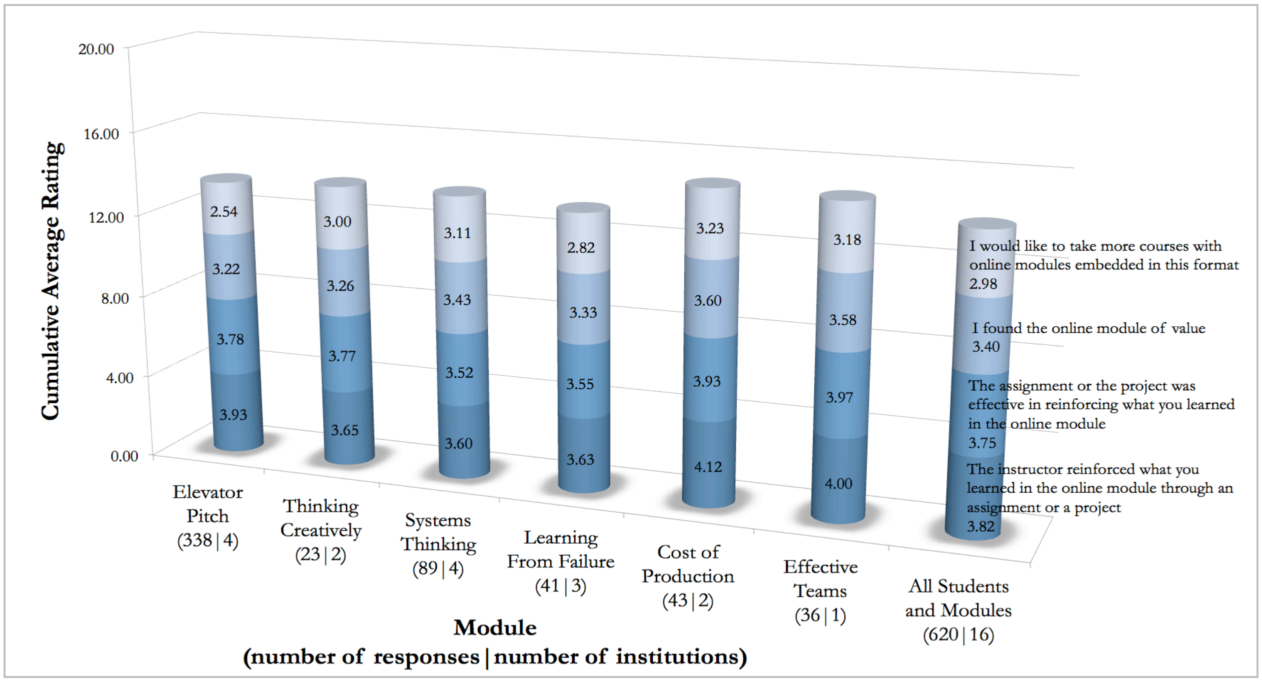

Figure 5 Average Student Ratings of e-Learning Modules

The results indicate that students generally agreed that the contextual activities completed in their courses were effective in reinforcing what they learned in the modules. On average, students found the e-learning modules to be of value. However, they were less supportive of having more classes with integrated e-learning modules. Open-ended responses from students varied widely ranging from finding the modules very effective, informational and helpful in gaining insights to finding them a waste of time or irrelevant to the course. This mixture of responses occurred for each module. Integrating the modules into existing courses increases the workload of students, so it is not particularly surprising that they have mixed feelings about the modules.

Findings and Discussion

The module specific pre and post surveys indicate that the e-learning modules are generally effective in enabling engineering students to learn the knowledge and skills required for developing an entrepreneurial mindset. The survey data raised concerns about the survey questions and content of the *Effective Teams* and *Cost of Production* modules. We will use the feedback to enhance the survey questions and content of these two modules.

The sample size for instructor feedback on each module was quite small, but collectively they constituted a reasonable number, and the overall metrics provided an understanding of faculty perception and expectations on the impact of the modules. The faculty responses indicate that: the e-learning modules collectively address all of the EML outcomes that the KEEN framework targets; and the contextual activities employed in classes cover the complementary skills included in this framework reinforcing what is learned in the module. The student feedback confirmed this finding. Faculty reported that the modules enhanced student learning in their class and were useful in developing an entrepreneurial mindset in students. The faculty rated their overall experience in implementing the e-learning modules as very good, which provides preliminary evidence on the effectiveness of the model we are using to instill EML in our engineering students.

Table 6 shows that compared to students, faculty valued the e-learning modules more and would like to see more of them integrated into courses. Students found the modules of value, but were neutral about having to take more courses with e-learning modules integrated into them. A key reason for students not wanting too many courses with e-learning modules is the extra workload. Furthermore, some students were not able to relate the topics covered in the modules with the course content. Providing students information at the beginning of the course on why an e-learning module is being integrated might help improve some of the student perceptions.

Table 6 Comparison of Student - Faculty Perceptions on e-Learning Modules

Stakeholder:	Student	Faculty	Student	Faculty
Module:	I found the online module of value.	Overall, I found the e-Learning module enhanced my course.	I would like to take more courses with online modules embedded in this format.	I am likely to adopt e-Learning modules on other topics of interest.
Thinking Creatively	3.26	4.50	3.00	4.50
Cost of Production	3.60	3.50	3.23	2.50
Learning from Failure	3.33	4.00	2.82	3.67
Elevator Pitch	3.22	4.75	2.54	4.50
Systems Thinking	3.43	3.75	3.11	4.00
Effective Teams	3.58	3.00	3.18	5.00
Overall	**3.40**	**3.92**	**2.98**	**4.03**

Conclusions and Future Work

Six e-learning modules developed at the University of New Haven were deployed at 25 institutions in the 2016-17 academic year. The findings based on data collected from the fall 2016 deployment are reported herein. The module specific pre and post surveys, and student and instructor feedback, provided preliminary positive evidence on the effectiveness of the e-learning modules in helping students improve their entrepreneurial thinking.

We are continuing to develop the remaining 8 e-learning modules. We are offering nine modules for external deployment in the 2017-18 mini-grant program. The pre and post surveys and faculty/student feedback forms provide data for indirect assessment of the effectiveness of the e-learning modules in developing an entrepreneurial mindset in engineering students. We will work on direct assessment approaches for the 2017-18 deployment.

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APPENDIX 1: Learning Outcomes for E-Learning Modules

Adapting a business to a changing climate
• Explain the ways in which new and existing firms are impacted by changing business conditions • Describe the various factors that make up market/business conditions • Perform environmental scanning on the business environment • Describe ways in which firms deal with changes in its business environment • Explain the mindset and characteristics of those people (and organizations) that survive and thrive given challenges and setbacks
Applying systems thinking to solve complex problems
• Define system, systems architecture, and system engineering • Decompose system hierarchy to at least four levels • Define any system from various perspectives, including technical feasibility, value, risk, and societal impact • Describe four methods of developing a system architecture • Apply the heuristic architecting method to develop a system architecture
Building, sustaining and leading effective teams and establishing performance goals
• Recognize the common phases of team development • Identify success factors at each stage of the team development process that influence productivity • Differentiate between consensus and compromise • Examine individual preferences' dichotomies found in a personality comparison instrument • Identify factors that influence actions and decision-making • Recognize four different viewpoints used to reach consensus • Relate the importance of team and individual performance to reaching overall objectives • Design a performance plan • Recognize what conflict is and ways it is manifested in project teams • Differentiate constructive from destructive approaches to conflict in teams • Identify ways to address conflicts in teams most productively
Cost of production and market conditions
• Identify the market scenarios for a product • Analyze the effects of different business models • Construct models that compare different growth scenarios • Describe the nature of the firm that will be best for the product and its environment • Explain the linkages between the production function and various costs and profits • Describe the behavior of costs in the short run and long run production • Identify economies of scale and dis-economies of scale through long run cost curves • Calculate the total cost of a bicycle (product) offered for sale in a retail store • Apply various methods to suggest a selling price based on the costs of production
The elevator pitch: advocating for your good ideas
• Identify the value proposition of a product or service from the point of view of a variety of stakeholders • Articulate the criteria that yield an effective pitch • Outline a process for developing elevator pitches • Implement strategies for recovering from an unsuccessful pitch experience
Developing a business plan that addresses stakeholder interests, market potential and economics
• Identify an innovative and differentiated business concept • Develop a strategy for returning value to economic stakeholders • Construct a business's value chain, showing the company's operational flow • Assess a business market opportunity, including competitive positioning • Develop market entry, growth and exploitation strategy • Develop key business plan assumptions and simulate business performance • Utilize resources to prepare valuable business plans

Developing customer awareness and quickly testing concepts through customer engagement
• Compare the process of testing concepts through customer engagement, driven by customer awareness, to examples of successful successive refinement, including evolution of the species and Boyd's OODA Loop • Analyze a proposed customer awareness technique relative to a stated product/service and market environment • Make inferences drawn from a primary source on the democratization of innovation
Learning from failure
• List common mistakes in the product development cycle for real world projects • Develop a list of practical options to correct or avoid potential mistakes that may occur in specific projects • Explain the potential risks of failure and proposed solutions in terms familiar to various stakeholders • Provide recommendations for deciding when to stop a project or when to continue it • Extract practical lessons learned by reviewing case histories of failures
Product in value creation
• Describe each element of the total product concept • Apply the Product^3 concept to past product successes and failures • Define the concept of value • Explain the value proposition canvas • Relate the Product^3 concept to the value proposition canvas • Evaluate value creation using the value proposition canvas
Thinking creatively to drive innovation
• Describe the meaning of creativity, a rare but achievable form of thinking • Explain the observation that creativity is influenced much more by nurture than nature • Describe the universality and power of the divergent-convergent thinking process • Apply the Medici Effect when forming teams • Apply the Ask-Ask-Ask method • Apply the Fishbone Diagramming method • Apply the Mind Mapping method

APPENDIX 2: Courses in which E-Learning Modules were Deployed

The elevator pitch: advocating for your good ideas	**Applying systems thinking to solve complex problems**
MECH 1208: Intro to Mechanical Engineering II BIOE 111: Bioengineering Innovation and Design STS 1500: Sci, Tech. and Contemporary Issues ES 250: Electrical Science ENGR 425: Reinforce Concrete Structures EECE 5001/5031, 5002/5032, EE/CompE Senior Design Senior Design Courses[*]	ME 391: Independent Study: Robotics and Mechatronics IE 326: Production Planning and Control MECH 432: Energy Systems (Sustainability Course) ChE 4131: Process Design I ECCS 4731: Capstone Seminar CIVL 4450: Steel and Concrete Design[*] Senior Design Courses[*]
Thinking creatively to drive innovation	**Learning from Failure**
GEEN 1120: Engineering Discovery EMGT 142: Design and Innovation BIOE 174: Microfabrication for Microfluidics ME 3295/MSE4095: Introduction to 3D Printing: Learn by Building ME 3100: Thermodynamics ENGR 498: Innovation EGR 401: Advanced Product Design ENGR 407: Technology-Based Entrepreneurship EASC 2213: Materials in Engineering Systems[*]	EGR 101: Intro to Engineering ES 231: Natures of Engineering Materials ChE 320/321: Applied Fluid Flow and Heat Transfer CE 336: Soil Mechanics ECCS 4731: Senior Design 2 EASC 1109: Project Planning and Development[*]
Cost of production and market conditions	**Building, sustaining and leading effective teams and establishing performance goals**
IME 255: Engineering Economy ME 3421: Manufacturing Processes EE 485/585: Engineering Operations EASC 2232: Project Management and Engineering[*]	ENG 1102: Engineering Modeling and Design ECT 110: Electrical Circuits EGE 2123: Entrepreneurial Engineering Design Studio CENG 3240: Unit of Operations Laboratory CIVL 409: Concrete Design ENGR 408: Leadership Principles Third Year Lab Courses[*]

[*]Courses at the University of New Haven

APPENDIX 3: Instructor Feedback Form

INTEGRATED e-LEARNING MODULES INSTRUCTOR FEEDBACK FORM

Please complete and submit this form with the following documentation:

- Your revised course syllabus reflecting integration of e-Learning module

- Any new or modified course assignment including the contextual activity linked to the module topic

Module Title *

Institution *

Course Code *

Course Title *

Deployment Term *

Instructor *

Pre-Survey Date *

/ /

MM DD YYYY

Deployment Start Date *

/ /

MM DD YYYY

Deployment End Date *

/ /

MM DD YYYY

Post-Survey Date *

/ /

MM DD YYYY

Please Provide your feedback on the following items:

1. Choose which Entrepreneurial Minded Learning (EML) outcomes you think this module targeted. (Check all that apply.)

CURIOSITY

- ☐ Demonstrate constant curiosity about our changing world
- ☐ Explore a contrarian view of accepted solution
- ☐ Other

CONNECTIONS

- ☐ Integrate information from many sources to gain information
- ☐ Assess and manage risk
- ☐ Other

CREATING VALUE

- ☐ Identify unexpected opportunities to create extraordinary value
- ☐ Persist through and learn through failure
- ☐ Other

Briefly explain why you think the module targeted the items you identified above.

2. In addition to having students complete the module, you employed multiple activities to engage students, reinforce, and assess learning as part of deployment of this module in your class. Choose the Entrepreneurial Minded Learning complementary skills (Opportunity and Impact) your activities targeted.

OPPORTUNITY

- ☐ Identify an opportunity
- ☐ Investigate the market
- ☐ Create a preliminary business model
- ☐ Evaluate technical feasibility, customer value, societal benefits, economical viability
- ☐ Test concepts quickly via customer engagement
- ☐ Assess policy and regulatory issues

IMPACT

- ☐ Communicate an engineering solution in economic terms
- ☐ Communicate an engineering solution in terms of societal benefits
- ☐ Validate market interest
- ☐ Develop partnerships and build a team
- ☐ Identify supply chains distribution methods
- ☐ Protect intellectual property

7. Please describe the challenges you experienced, if any, during the deployment of the online module.

- ☐ Students felt overwhelmed to complete the module.
- ☐ I felt overwhelmed to reinforce completion of the module.
- ☐ Students found completing the module and related activities to be a burden.
- ☐ Students had difficulty in connecting the module to the content of the course.
- ☐ I had difficulty in integrating the module topic into my course.
- ☐ Other

8. If you were to deploy this module again in this course, please let us know what you would do differently in the deployment process.

9. Please list any suggestions for additions, subtractions and changes in the content of the module that will make the module better suited for it's topic.

10. Identify, if experienced, any technical issues with accessing the module material in your Learning Management System (Blackboard, Canvas, Moodle, etc.). (Check all that apply.)

- ☐ 1. No technical issues encountered.
- ☐ 2. Issues encountered during the content import.
- ☐ 3. Module content did not display properly in my LMS.
- ☐ 4. Students experienced technical problems while completing the online module.
- ☐ 5. Links for online surveys were not received.
- ☐ 6. Survey links did not work.
- ☐ Other

If you selected 2, 3, or 4, please let us know the nature of the problem.

11. Please rate how useful you found the e-Learning module in each of the following:

	Very Useful	Somewhat Useful	Neutral	Not Very Useful	Not At All Useful
Providing material that leads to student learning in the module topic	○	○	○	○	○
Enhancing student learning in the context of your class	○	○	○	○	○
Triggering student curiosity into new areas	○	○	○	○	○
Developing an entrepreneurial mindset in students	○	○	○	○	○
Expanding the boundaries of traditional classroom-based learning	○	○	○	○	○
Enriching course content without giving up class time for other topics	○	○	○	○	○

12. Do you have any prior teaching/learning experience with e-Learning? (Check all that apply.)

- ☐ Teaching
- ☐ Learning
- ☐ None

13. Please select how much you agree/disagree with each statement.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Overall, I found the e-Learning module enhanced my course.	○	○	○	○	○
I was able to appreciate the value of e-Learning by deploying this module.	○	○	○	○	○
I am likely to adopt e-Learning modules on other topics of interest.	○	○	○	○	○
I am likely to recommend these e-Learning modules to my colleagues.	○	○	○	○	○

14. Please list topics not included in the module list drop down menu above that you think would be useful as an EML module in your courses.

15. Please add any other comments you want to share with us regarding the e-Learning modules.

16. Please rate your overall experience in implementing this e-Learning module.

- ○ Excellent
- ○ Very good
- ○ Good
- ○ Fair
- ○ Poor

Would you be willing to let us use your comments as a testimonial? *

- ☐ Yes
- ☐ No

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