Integrating e-Learning Modules into Engineering Courses to Develop an Entrepreneurial Mindset in Students

Dr. Nadiye O. Erdil, University of New Haven

Nadiye O. Erdil is an assistant professor of industrial engineering and engineering and operations management at the University of New Haven. Her research interests include use of statistical methods and lean tools for quality and process improvement, and use of information technology in operations management. Her work is primarily in manufacturing and healthcare delivery operations.

Dr. Ronald S. Harichandran, University of New Haven

Ron Harichandran is Dean of the Tagliatela College of Engineering and is the PI of the two grants entitled "Project to Integrate Technical Communication Skills" and "Developing entrepreneurial thinking in engineering students by utilizing integrated online modules and experiential learning opportunities." Through these grants technical communication and entrepreneurial thinking skills are being integrated into courses spanning all four years in seven ABET accredited engineering and computer science BS programs.

Dr. Jean Nocito-Gobel, University of New Haven

Jean Nocito-Gobel, Professor of Civil & Environmental Engineering at the University of New Haven, received her Ph.D. from the University of Massachusetts, Amherst. She has been actively involved in a number of educational initiatives in the Tagliatela College of Engineering including KEEN and PITCH, PI of the ASPIRE grant, and is the coordinator for the first-year Intro to Engineering course. Her professional interests include modeling the transport and fate of contaminants in groundwater and surface water systems, as well as engineering education reform.

Dr. Maria-Isabel Carnasciali, University of New Haven

Maria-Isabel Carnasciali is an Assistant Professor of Mechanical Engineering at the Tagliatela College of Engineering, University of New Haven, CT. She obtained her Ph.D. in Mechanical Engineering from Georgia Tech in 2008. She received her Bachelors of Engineering from MIT in 2000. Her research focuses on the nontraditional engineering student – understanding their motivations, identity development, and impact of prior engineering-related experiences. Her work dwells into learning in informal settings such as summer camps, military experiences, and extra-curricular activities. Other research interests involve validation of CFD models for aerospace applications as well as optimizing efficiency of thermal-fluid systems.

Dr. Cheryl Q. Li, University of New Haven

Cheryl Qing Li joined University of New Haven in the fall of 2011, where she is a Senior Lecturer of the Industrial, System & Multidisciplinary Engineering Department. Li earned her first Ph.D. in mechanical engineering from National University of Singapore in 1997. She served as Assistant Professor and subsequently Associate Professor in mechatronics engineering at University of Adelaide, Australia, and Nanyang Technological University, Singapore, respectively. In 2006, she resigned from her faculty job and came to Connecticut for family reunion. Throughout her academic career in Australia and Singapore, she had developed a very strong interest in learning psychology and educational measurement. She then opted for a second Ph.D. in educational psychology, specialized in measurement, evaluation and assessment at University of Connecticut. She earned her second Ph.D. in 2010. Li has a unique cross-disciplinary educational and research background in mechatronics engineering, specialized in control and robotics, and educational psychology, specialized in statistical analysis and program evaluation.

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Abstract

Engineering graduates who will be leaders in today's rapidly changing environment must possess an entrepreneurial mindset and a variety of professional skills in addition to technical knowledge and skills. An entrepreneurial mindset applies to all aspects of life, beginning with curiosity about our changing world, integrating information from various resources to gain insight, and identifying unexpected opportunities to create value. The Kern Entrepreneurial Engineering Network (KEEN) defines *curiosity*, *connections* and *creating value* as three core components of an entrepreneurial mindset. These 3*C*s coupled with associated engineering skills forms KEEN's entrepreneurial mindset framework. An entrepreneurial mindset enables engineers to develop sound technical solutions that address customer needs, are feasible from a business perspective, and have societal benefit.

The Tagliatela College of Engineering at the University of New Haven is working to develop an entrepreneurial mindset in its engineering students through a four-faceted framework based on KEEN's constructs that includes: 1) developing an entrepreneurial mindset amongst faculty; 2) providing curricular components that develop specific student knowledge and skills; 3) structuring the physical environment to promote entrepreneurial minded learning; and 4) providing opportunities for students to engage in meaningful extra-curricular activities. This paper focuses on the curricular component of this framework.

As part of these curricular activities, 18 short, self-paced, e-learning modules will be developed and integrated into courses spanning all four years across all engineering and computer science disciplines. Each module contains readings, short videos and self-assessment exercises. Five of these e-learning modules were developed in fall 2014, four of these five were piloted in the Spring 2015 semester, and all five modules were broadly deployed in the Fall 2015 semester. A flipped classroom instructional model is used to integrate the modules into courses. Content is delivered via a short online module outside the class, and student learning is improved by reinforcing the content covered in the module through class discussions and contextual activities. Direct and indirect assessment is performed through formative and summative class assessments and module specific pre and post surveys, respectively.

The five integrated e-learning modules presented in this paper are: 1) Developing customer awareness and quickly testing concepts through customer engagement, 2) Learning from failure, 3) Cost of production and market conditions, 4) Building, sustaining and leading effective teams and establishing performance goals, and 5) Applying systems thinking to solve complex problems. The first two modules were integrated into freshman classes, the third into a sophomore class, the fourth into third year laboratory courses, and the fifth into senior design courses. This paper describes the learning outcomes and the reinforcement activities conducted in the courses into which they were integrated for two of these modules. The findings of the module specific surveys and the assessment results are also presented.

Introduction

Having good technical skills is necessary but insufficient by itself for an engineering graduate to develop as a leader and innovator.[1] In today's environment, engineering graduates must also possess an entrepreneurial mindset and a variety of professional skills to be leaders. The Kern Entrepreneurial Engineering Network (KEEN) defines three core components of an entrepreneurial mindset: (1) having *curiosity* to investigate a rapidly changing world; (2) showing the ability to innovate by making *connections* between different streams of information; and (3) striving to *creating value* for others. These 3*C*s coupled with associated engineering skills form KEEN's entrepreneurial mindset framework.

An entrepreneurial mindset enables engineers to develop sound technical solutions that address customer needs, are feasible from a business perspective, and have societal benefit. However, expanding existing engineering curricula to include new topics, such as the development of an entrepreneurial mindset and skills, is difficult without exceeding typical credit limits of engineering programs.[2] The Tagliatela College of Engineering at the University of New Haven is working to develop an entrepreneurial mindset in its engineering students based on KEEN's 3*C*s through short e-learning modules that are integrated into existing courses. Enriching curriculum in this manner can be done without additional credit allocations. In this effort, we take advantage of the e-learning environment. Although the effectiveness of e-learning has been questioned by some, [3] the literature reveals that e-learning courses are equally effective as traditional lecture courses in meeting student outcomes.[4, 5, 6]

Most research regarding e-learning has focused on understanding the perception of e-learning methods by faculty and students.[7, 8, 9, 10] For instance, Tanner et al.[9] highlighted that student and faculty attitude toward e-learning were directly linked to their own comfort level with the e-learning environment. Davis emphasized that perceived usefulness of a technology as well as the ease of use of that technology were the two primary factors confirming the *intention* to use and deploy it. [7]

Disciplines such as healthcare and law have long been using distance learning to train and certify large numbers of individuals without geographical restrictions or scheduling logistics. Entire engineering programs may now be pursued online[11] and MOOC offerings continue to explode.[12] However, adoption of online methods to supplement or support traditional classroom teaching has been more limited.[6] The recent popularity of flipped classroom methodologies to enhance student learning has increased the use of resources such as videos[13, 14] and online resources.[15, 16]

To enable *all* engineering and computer science students to learn the many concepts associated with entrepreneurial thinking, the Tagliatela College of Engineering at the University of New Haven is adopting online methods that develop specific student knowledge and skills. Specifically, 18 e-learning modules will be developed and integrated into regular engineering courses. The titles of the e-learning modules and the courses into which they will be integrated are specified in Table 1. Modules 2-5, 12, 14 and 16 have been developed and modules 2, 4, 5, 12, 14 and 16 were integrated into courses at the University of New Haven in 2015 and into courses at Lafayette College, Ohio Northern University, Santa Clara University, the University of Dayton and Villanova University in spring 2016.

Table 1. E-learning modules and target courses into which they will be integrated

e-Learning Modules	Target Courses for Integration of Modules
1. Generating new ideas based on societal needs and business opportunities	Introduction to Engineering (Freshman)
2. Developing customer awareness and quickly testing concepts through customer engagement*	
3. Thinking creatively to drive innovation†	Project Planning and Development (Freshman)
4. Learning from failure*	
5. Establishing the cost of production or delivery of a service, including scaling strategies*	Project Management and Engineering Economics (Sophomore)
6. Determining market risks	Applied Engineering Statistics (Junior)
7. Designing innovatively under constraints	(Junior Courses) Transport Operations II Mechanics and Structures Lab Software Project Analysis and Design Junior Design Laboratory Fundamentals of Mechanical Design System Engineering Concepts and Design
8. Financing a business	Engineering Entrepreneurship (Junior level course being developed)
9. Developing a business plan that addresses stakeholder interests, economics, market potential and regulatory issues	
10. Marketing a product or service	
11. Adapting a business to a changing climate	
12. Delivering an elevator pitch†	
13. Resolving difficult ethical issues	(Junior Courses) Professional Engineering Seminar Social & Professional Issues in Computing Professional and Ethical Practice
14. Building, sustaining and leading effective teams and establishing performance goals*	(Junior Courses) Chemical Engineering Laboratory Soil Mechanics Laboratory Junior Design Laboratory Mechanics Laboratory System Engineering Design Process
15. Building relationships with corporations and communities	Mandatory internships
16. Applying systems thinking to complex problems*	Disciplinary Senior Design Courses
17. Recruiting and servicing clients	
18. Defining and protecting intellectual property	

* Modules broadly deployed in fall 2015 †Modules developed but not yet deployed

Process of Developing e-Learning Modules

An open solicitation process was used to seek content experts familiar with the topics listed in Table 1 to develop each e-learning module. Each module was designed to take 5-9 hours of work for a student to complete. Requests for proposals were issued to faculty at the University of New Haven, those at other institutions and industry consultants. Review teams of 2-3 faculty from the University of New Haven and other institutions who are familiar with KEEN goals were established to suggest detailed topics for each module and review modules through the development process. Potential developers submitted their proposals using a concise form provided to them. The authors and a program director of the granting agency reviewed the proposals received to select a developer for each module. The developers completed a one-week long online course prepared by the Office of eLearning at the University of New Haven to learn how to develop effective and interactive e-learning modules. The developers also participated in a webinar to familiarize themselves with entrepreneurial thinking, KEEN's goals and the elements they should include in the modules. Subsequently, the developers worked with a course designer to finalize an outline, detailed storyboards, and content. At critical points the review teams reviewed the submissions from developers and provided them feedback. After all of the content was developed, the course designer formatted them into the Blackboard learning management system (LMS).

Implementation Framework

At the Tagliatela College of Engineering, modules are integrated into courses using a flipped classroom model. In each course, content is delivered via a short e-learning module outside the class, and student learning is improved by reinforcing the content covered in the module through class discussions and contextual activities. The overall integration has the four main components shown in Figure 1. Students complete the e-learning module outside the class within two weeks. During the second week, students are asked to participate in an online or in class discussion. The discussion questions enable students to learn through peer and/or instructor interaction. After completion of the module, students are required to work on a class project related to the module topic. A final assessment is done either through questions included in the final exam or through mini-assignments. The class project is typically an existing project that is modified to include material covered in the e-learning module. However, they can also be assignments that are specifically designed to target learning outcomes that are linked to the module content.

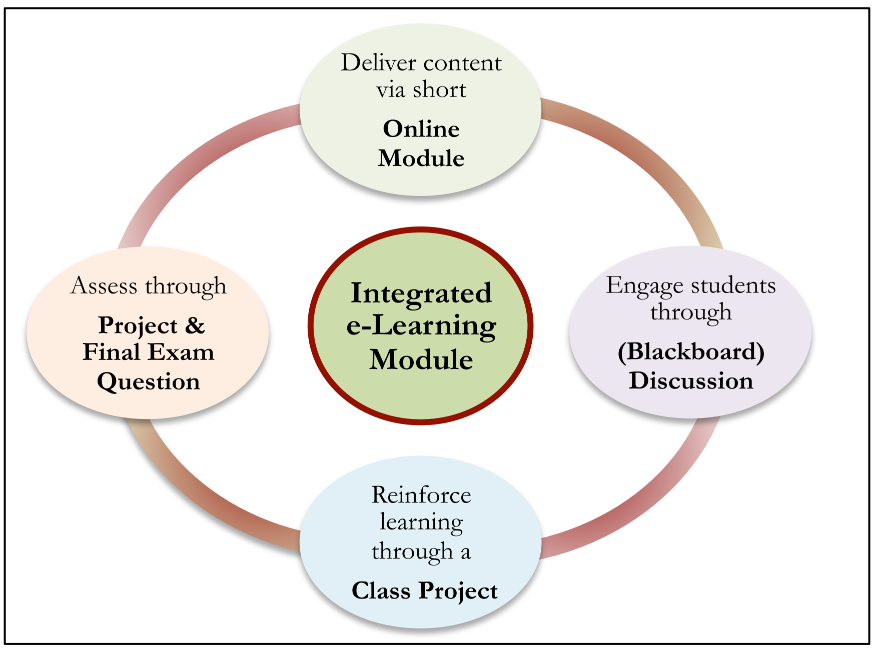

Figure 1. Integration components of e-Learning modules

Instructors are asked to perform the following to integrate e-learning modules into their classes:

1. Complete the e-learning module;
2. Attend training designed for faculty deploying the modules;
3. Revise course syllabi to reflect integration of e-learning module into the course;
4. Plan how to reinforce content in the online module with a contextual activity in the course;
5. Revise course syllabi to include the contextual activity and the learning outcomes;
6. Administer a module-specific survey in the second week of class;
7. Deploy the e-learning module;
8. Implement the contextual activity in the course;
9. Administer the module specific survey again during the last week of class;
10. Conduct summative assessment by evaluating performance on the contextual activity and/or final exam questions;
11. Communicate module-specific activities to those coordinating the program;
12. Complete a short reflection survey;

The five modules marked with an asterisk (*) in Table 1 were broadly deployed in fall 2015 in multiple sections of target courses. Specifically, module 2 was deployed in eight sections of the Introduction to Engineering course, module 4 in five sections of the Project Planning and Development course, module 5 in three sections of the Project Management and Engineering Economics course, module 14 in two disciplinary laboratory courses, and module 16 in five disciplinary senior design courses. The main criterion used to assign a module to a specific course was the level of benefit students would receive from the content of the module in the course. The benefit was assessed based on the relevance of the material covered in the module to the course content and the course learning outcomes. Table 2 provides an explanation of the specific contributions from each of the modules to the targeted course.

Table 2 also shows when in a four-year program the five e-learning modules are completed by students. The overall design of the e-learning modules program was done in such a way that when all 18 modules are integrated into the curriculum, all engineering and computer science students will complete at least 12 of the 18 modules and at least one module at each class level; and some will complete all 18 modules.

Implementation of Selected Modules

In this section, we present the implementation details for two of the modules listed in Table 2: (1) Learning from Failure, and (2) Building, Sustaining and Leading Effective Teams and Establishing Performance Goals.

Learning from Failure: Online Module Summary

The e-learning module *Learning from Failure* provides students knowledge to explain the potential risks of failure, i.e., identify what can go wrong, propose solutions that identify how to plan or react quickly to avoid issues that can cause a project to fail, and in case of failure develop strategies to deal with the outcomes. The module aims to show students that failure is sometimes inevitable and can be a valuable experience even though engineers are often taught they should avoid failure. The module provides several case studies that demonstrate how knowledge gained from failures can be used to improve designs, products, and processes. The learning outcomes of the e-learning module are to:

Table 2. Contribution of e-learning modules to the courses into which they are integrated

Class Level	*Course*: Module	Skills Targeted in the Module	Relevance
Freshman	*Introduction to Engineering*: Developing customer awareness and quickly testing concepts through customer engagement	Investigate market, and test concepts quickly via customer engagement	This is an active learning, project-based course. It includes four class projects that introduce students to basic engineering concepts in product design. The module enriches the content of the course by providing students an overview of methods used for bringing design to market rapidly through customer engagement.
Freshman	*Project Planning and Development*: Learning from Failure	Accept the possibility of failure, persist in the face of failure, and learn from the experiences to achieve objectives	This is a project-based course that develops skills to successfully plan and implement selected projects within budgetary and time constraints. The module provides students knowledge to explain potential risks of failure, i.e., identify what can go wrong, and propose solutions that identify how to plan or react quickly to avoid issues that can cause a project to fail.
Sophomore	*Project Management and Engineering Economics*: Establishing the cost of production or delivery of a service, including scaling strategies	Identify an opportunity, investigate a market, create a preliminary business model, and evaluate technical feasibility, customer value, societal benefits, and economic viability	In this course students are introduced to economic analysis with an emphasis on those concepts directly related to project management, as well as to the analysis of alternatives under risk and uncertainty. The module enhances learning by informing students how to apply various costs to evaluate the economic viability of a product or service with respect to various market conditions.
Junior	*Third Year Lab Courses*: Building, sustaining and leading effective teams and establishing performance goals	Recognize the team life cycle, identify success factors that influence productivity, recognize factors that influence decision-making tied to personality, and identify the importance of both team and individual performance to achieve overall team objectives.	These courses have team-based projects, and the module provides students the necessary guidance to assess team dynamics and performance, and have a better understanding of their role in an effective team. Furthermore, integration at this level provides an early intervention to help prepare students before their senior design projects, which are also team-based.
Senior	*Senior Design Courses*: Applying systems thinking to complex problems	Learn to use some tools such as function mapping and decomposition to apply systems thinking to complex problems	Senior design projects involve design of a part, subcomponent or a system. To effectively perform design tasks, understanding of form and function as individual elements and as part of a whole is critical. Systems thinking enables looking at parts of a system as individual components as well as a whole, and systems engineering provides tools and methods to bring a system's architecture by formulating problems in terms of functional requirements.

1. List common mistakes in the product development cycle for real world projects.
2. Develop a list of practical options to correct or avoid potential mistakes that may occur in specific projects.
3. Explain the potential risks of failure and propose solutions in terms familiar to various stakeholders.
4. Provide recommendations for deciding when to stop a project and when to continue it.
5. Extract practical lessons learned by reviewing case histories of failures.

Collectively, the content presented in the module aims to help engineers recognize situations where failure could happen, not to be averse to failure but take risks, persist in the face of failure and learn to turn failure into a positive learning experience. Example content from the module is shown in Figure 2.

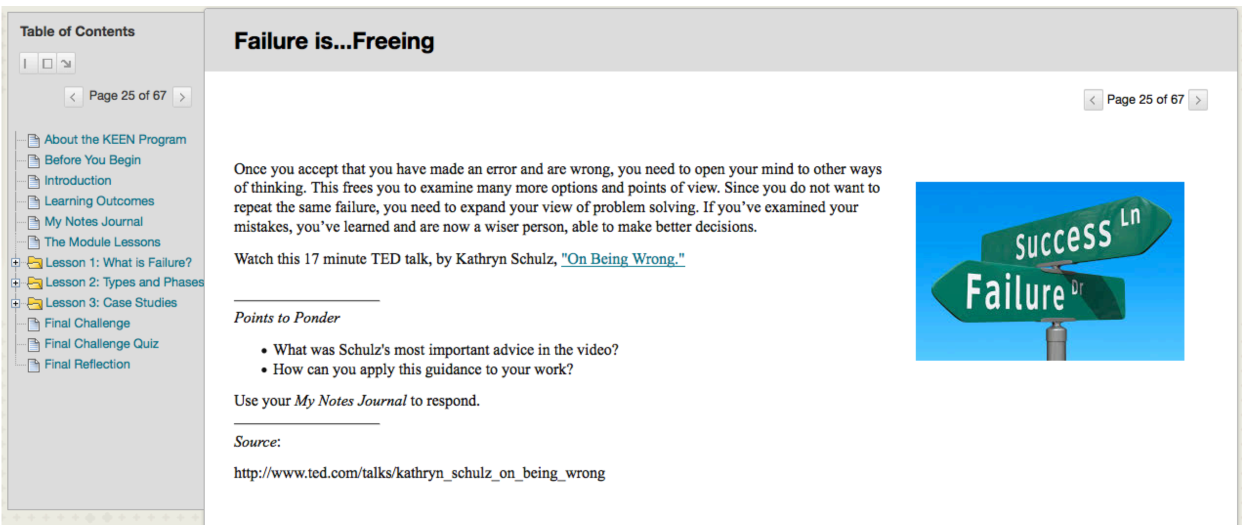

Figure 2. *Learning from Failure*: Leads to better decisions through problem solving

This module is integrated into a project-based freshman course that aims to develop basic time management, leadership and project management skills, to highlight the application of engineering topics in several different areas of engineering, and to introduce measurement and control of simple processes. Students gain proficiency in these areas as they complete a series of projects spanning the course. The module *Learning from Failure* is a perfect fit for this class because in most of the class projects students are likely to face failures and they are then expected to seek alternative solutions.

As described in the previous section, the deployment of an e-learning module consists of delivering content via an online module, conducting online discussions, reinforcing learning through a contextual activity, and performing a final assessment by evaluating the contextual activity and/or final exam questions. The deployment timetable of the *Learning from Failure* e-learning module in the Project Planning and Development course is shown in Table 3.

Table 3. *Learning from Failure* – Deployment timetable

Activity	Week
Pre-survey	6
Online module completion	7-8
Blackboard discussion questions	8
Contextual activity (class project)	8-12
Post survey	14
Final assessment	16

***Learning from Failure:* Discussion Questions**

The online discussion assignment linked to the module content aimed to provide students a platform to help formulate a strategy in case of failure and assess its effectiveness through peer discussion. The discussion questions with teaching notes are shown in Appendix A.

***Learning from Failure:* Contextual Activity**

The e-learning module content was linked to an existing design project that was revised to bring an emphasis on failures that students go through during the implementation of the project. In this design project students are asked to work as a team and with all the teams in class to create a work-cell plant layout that will allow their robot to deliver parts from their platform to the next group's platform. The teams control the movement of their robot using a computer program they write. The overview for this manufacturing and robotics design project is given in Appendix B.

The contextual activity targeted two of the learning outcomes of the module: (1) to develop a list of practical options to correct or avoid potential mistakes that may occur in specific projects; and (2) to explain the potential risks of failure and propose solutions in terms familiar to various stakeholders. The students were asked to complete reflections on their learning experiences from failure in their written report by addressing the following questions:

- From the lessons learned in the *Learning from Failure* online module, list what could have been done differently to avoid the mistakes that occurred implementing this project.
- Discuss what the potential risks of failure are for a project like this if done in industry, and propose solutions for these risks in terms familiar to various stakeholders.

***Learning from Failure:* Final Exam and Overall Assessment**

The final component of deploying the module in the course was an assessment using final exam questions. Students were asked to consider several scenarios, some hypothetical and some real, and answer questions that get them to think about the case from a perspective of failure.

The online module also has a final challenge and students must achieve 80% or greater to successfully complete the module. The proportion of the final grade assigned to the various assessment activities were as follows: successful completion of the module: 5%; discussion questions: 1%; component of class project related to the module: 2.7%; final exam questions related to the module: 3%. Thus, the proportion of the total grade allocated to components related to the e-learning module was close to 12%.

***Building, Sustaining & Leading Effective Teams:* Online Module Summary**

The e-learning module *Building, Sustaining & Leading Effective Teams* provides students knowledge on the formation and functioning of effective teams including: the stages of team development; strategies for reaching consensus when making decisions; relationship between individual preferences for decision-making and team performance; and tools to enhance team effectiveness. Students learn that effective teams just don't occur accidentally, but there are specific strategies and tools that can be used to increase team productivity. Students explore their own individual approaches to problem solving using the Myers-Briggs Type Indicator instrument before examining the impact that their individual personalities can have on the team. The learning outcomes of the module are:

1. Define a team.
2. Recognize the team life-cycle model.
3. Identify success factors at each stage of the team development process that influence productivity.
4. Differentiate between consensus and compromise.
5. Examine individual preferences' dichotomies found in a personality comparison instrument.
6. Identify factors that influence actions and decision-making.
7. Recognize four different viewpoints used to reach consensus.
8. Relate the importance of team and individual performance to reaching overall objectives.
9. Design a performance plan.

The e-learning module uses personal experiences and case scenarios to explore how these tools and strategies impact decision-making on teams. Example content from the module is shown in Figure 3.

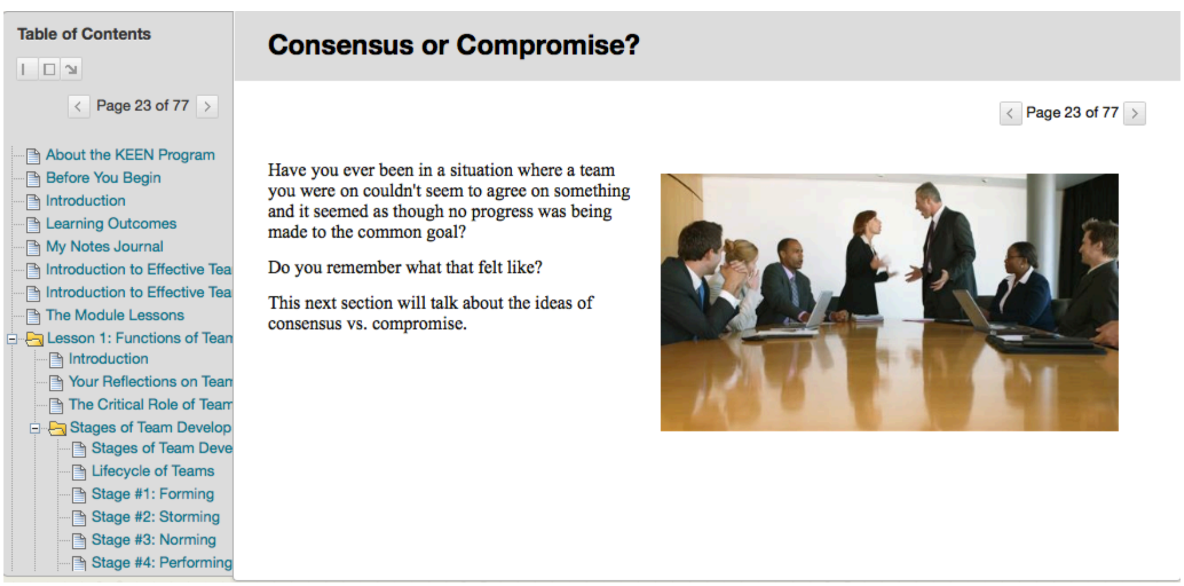

Figure 3. *Building, Sustaining & Leading Effective Teams*: Example module content

The e-learning module was deployed in two disciplinary laboratory courses during the fall 2015 semester. Process Dynamics and Control with Lab is the first of two laboratory courses taken by chemical engineering majors. Students gain experience with pilot scale process equipment through experiments that focus on fundamental principles of chemical process dynamics used in the measurement and control of process variables. Mechanics Laboratory is a junior-level mechanical engineering course. Students perform experiments in mechanics of materials and vibrational analysis using computer-aided data acquisition systems. Both laboratory courses require students to work in teams to perform experiments, analyze data and write laboratory reports, and thus these courses align well with the outcomes of the e-learning module on team building.

Deployment consisted of delivering content via the online module and reinforcing learning through a contextual activity. Although students completed the online module on their own, the laboratory environment allowed for in-class discussions. Table 4 outlines the deployment timetable in the two courses.

Table 4. *Building, Sustaining & Leading Effective Teams* – Deployment timetable

Activity	**Week Chemical Engr. Lab**	**Week Mechanical Engr. Lab**
Pre-Survey	3	7
Online module completion	4-5	9
In-class discussions on e-learning module	5	10
Contextual Activity	6-11 4 Team Charters	10 -13 Experimental Design Project
Post Survey	14	14

Building, Sustaining & Leading Effective Teams: **Contextual Activity**

Both laboratory courses enhanced team performance by linking the online module content with team-based experiments. Students in the chemical engineering laboratory course prepared team charters included as an appendix to the planning reports for three of the experiments and the final project. A team charter is a written document that helps determine what the team wants to achieve, and how it is going to be successful. Prior to deploying the e-learning module, students formed teams to conduct the initial experiment in the lab. After completing the e-learning module, new teams were established following an in-class discussion focused on forming teams using the stages of team development. Students returned to their original teams for the final design project.

During one laboratory class, the instructor led a discussion on individual perceptions following completion of the e-learning module. Students were asked to create questions that would be specific to one of the assigned labs that could be asked using the ORID (Objective, Reflective, Interpretive, and Decisional) process. This process uses question prompts to explore problems from four different viewpoints with the intent of helping teams come to a consensus.

Upon completion of the final project, students wrote a final reflection on how their group used the team charter, how they overcame challenges, and how well they worked as a team for their final project. This reflection was used to evaluate group performance using feedback from student peers. Questions included in the group work reflection are listed below.

1. How well did your group work together on the final project? You should comment on how well work was distributed and completed among group members as well as how well group members communicated and got along.
2. What challenges did your group face for the final project and how did you overcome them?

3. Was it helpful to create a team charter for your projects and would you do this in the future? (This question is about other projects you did during the year)

In addition, students were asked to complete a survey identifying the contributions of their teammates. This survey, along with the reflection, allowed the instructor to evaluate how well students worked in their teams.

The mechanical engineering laboratory course integrated the six-element team performance model to enhance team effectiveness in a four-week final design project. Students were required to complete a team-based experimental design project on any approved topical area related to mechanical systems. Teams were instructed to assign specific roles for each team member. Students applied the six-element approach to manage their own team activity as a group. Each team submitted a document describing the six elements of student teams and how their team intended to implement them as part of their final project.

***Building, Sustaining & Leading Effective Teams:* Overall Assessment**

The overall assessment of learning in the chemical engineering laboratory course included completing the online module and assessing how well each student worked in their teams based on peer evaluations. The online module had a final challenge, for which the students must achieve 80% or greater to successfully complete the module. Successful completion of the module constituted 5% of the overall course grade. Planning reports contributed to 20%, and effectiveness of working on teams was 5% of the final grade. Since team charters were 10% of the planning reports, they contributed to 2% of the overall course grade. The proportion of the total grade allocated to activities related to the e-learning module was close to 12%.

Overall assessment of learning in the mechanical engineering laboratory course was similar to the chemical engineering laboratory course. However, the proportion of the total grade allocated to activities related to the e-learning module was only 5% based on completion of the e-learning module and submission of the six-element team performance plan. However, team performance did not explicitly contribute to the final course grade. A score of 80% or greater on the final challenge defined successful completion of the e-learning module.

Assessment

A preliminary assessment study was conducted using the results of the pilot deployment of the *Learning from Failure* e-learning module. Two types of assessment were conducted to evaluate potential benefits gained from the integrated e-learning modules. The first was assessment of improvement in students' behavior/mindset in engineering entrepreneurship with respect to a specific module through survey responses. This was a two-step assessment with the pre-survey administered before the deployment of an e-learning module, and the post-survey taking place after completion of the e-learning module and the contextual activity. The students took the same module specific survey in the pre- and post-assessment. The pre- and post- survey results were then compared and analyzed to measure changes in students' mindset.

There were 8 questions in the survey. Students were asked to rate their agreement level on a five-point Likert scale. An additional choice "I don't know" was also included in the survey to discourage students from rating a statement when they did not understand what it meant. Figure

4 presents the survey of the e-learning module *Learning from Failure*, and Table 5 shows the analysis of the results. All pre-test and post-test means were adjusted so that the direction of improvement for all questions was the same. In this case, an increase in the post-test mean shows an improvement in student responses. Before administering the e-learning module, the "I don't know" option was checked 34 times. This number was reduced to 4 at the completion of the module, which supports our assertion that the e-learning modules help students acquire knowledge about the topics they cover. The means for 2 out of the 8 questions improved significantly showing that the e-learning modules could potentially help students develop an entrepreneurial mindset.

Learning from Failure

Please select how much you agree/disagree with each statement, if you don't understand the question, check "I don't know"

		Strongly Agree 5	Agree 4	Neutral 3	Disagree 2	Strongly Disagree 1	I don't know 6
1	Engineers typically view failure of engineering projects differently than failure of entrepreneurial ventures						
2	If an entrepreneur fails publicly, it is likely to ruin his or her career for life						
3	Failure can always be avoided through careful analysis						
4	It is better to avoid several failures at the start of an entrepreneurial venture and possibly have only one significant failure at the end						
5	Failure always occurs due to personal shortcomings						
6	If you encounter failure early in a project, you are less likely to encounter failure subsequently.						
7	Most successful entrepreneurs have failed many times in the past, and do not expect to fail anymore in the future						
8	Evaluating risk and assessing the consequences of failure is more important for engineering projects than for entrepreneurial ventures						

Figure 4 *Learning from Failure*: Module specific survey

Table 5. *Learning from Failure*: Improvement in student perspectives

		Total	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
I don't understand the question	Pre-test	34	8	3	1	9	2	1	3	7
	Post-test	4	1	1	0	1	0	0	0	1
			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Mean comparison	Pre-test		1.20	1.97	1.77	2.17	2.61	1.80	2.26	1.57
	Post-test		1.27	2.54	2.47	2.70	3.00	1.89	2.55	1.57
	Difference		0.07	0.57	0.70	0.53	0.39	0.10	0.30	0.00
	Percent Improvement		5.8%	28.9%	39.5%	24.4%	14.9%	5.0%	12.8%	0.0%

The second type of assessment evaluated student knowledge acquisition from the e-learning module. The direct assessment was conducted using regular class assignments, final exams and class discussions as explained in the Implementation Framework section above. The direct assessment results of the *Learning from Failure* e-learning module are shown in Table 6. There were four components in this assessment: online module completion, online discussion, contextual activity and module final exam. All students participated in the contextual activity and final exam assessments, 85.7% of the students completed the online module, but only 35.7% of them join the online discussion. The average grades for all the assessment components varied from 80 to 93.6, which demonstrated very good learning.

Table 6. *Learning from Failure*: Direct assessment results

Performance Indicator	KEEN Online Module Grade	KEEN Online Discussion	Contextual Activity Robotics Project	KEEN Module Final Assessment
% of students completing the assignment	85.7%	35.7%	100%	100%
Average grade in each assignment (out of 100)	93.6	93.0	89.8	80.0

Conclusions

Engineering graduates should possess an entrepreneurial mindset and skills in order to become better at identifying opportunities to create value. An entrepreneurial mindset will allow them to use their technical skills effectively in turning opportunity to an achievement that has societal and economic value. Engineering students with entrepreneurial training are therefore expected to begin their career with a competitive advantage. To develop entrepreneurial engineers, the Tagliatela College of Engineering at the University of New Haven is enriching its curriculum by integrating e-learning modules into regular engineering courses. When complete, there will be 18 e-learning modules targeting various entrepreneurial concepts and skills based on the KEEN Framework. In this paper, the approach of integrating the e-learning modules into regular engineering courses is described. Preliminary assessment results obtained from the pilot deployment of these e-learning modules are also presented. The results show that the integrated e-learning modules can be effective in increasing students' level of content knowledge.

Future work will involve continuing assessment activities as more e-learning modules are integrated into courses to identify strengths, revisions needed in modules, and adjustment needed in the integration. Full deployment of the five modules discussed will be completed by the end of spring 2016. Statistical analyses will be performed to evaluate the impact of the integrated approach as more student data is collected. The five modules described in this paper were deployed at five other institutions in spring 2016 and data that will help assessment will become available from those institutions as well. Additional efforts are being taken to broaden the deployment at other institutions.

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Appendix A - *Learning From Failure* - Discussion Questions

Open-Ended Problem: Recommend a Turnaround Strategy

Learning Objective:

- Explain the potential risks of failure and proposed solutions in terms familiar to various stakeholders.

Teaching Note: This discussion thread can be offered near the end of the module or after the module is completed as a class assignment. You can use this discussion as a group exercise in class (with modification) or use a learning management system to complete it online.

Task: Find and research a company/product on the brink of failure. Take the reins of the company/product and recommend a turnaround strategy.

Instructions:

Initial Post

Create a thread (online discussion option) that outlines your strategy based upon what you have learned in the module.

Follow up Discussion

After reviewing the responses of your peers, consider whether their strategy will be successful.

Respond to Posts

Review and comment on at least two other posts in the follow up discussion. Follow netiquette protocol and extend off (add to) an observation and or comment on an insight you had not considered.

Appendix B - Manufacturing & Robotics Project – Project Overview

EASC1109
Manufacturing & Robotics Project

Overview

This design project involves the use of an existing robotic design to integrate into a 3-6 work-cell plant layout based on a number of specific design criteria. The project is divided into three major components. The first is to use the modeling package provided to create a layout model of the platform, showing exact position and orientation of the platform in the room for other groups to work with. Second, working with the other groups in class over the Internet only, determine the exact location of your platform, find out the exact location of the next group's platform, and the required movement of your robot to pass the part from your platform to the next group's platform. Third, based on the geometric, time, power and motion constraints, write the computer program to control the robot. Each team gives weekly 2-3 minute status reports (in PowerPoint) to the class; establish detailed project management documentation (Gantt, deployment, cpm) describing the sequence of activities and keep records as to the actual progress made. Each team meeting must follow a published agenda established from a previous meeting. Team members will alternate responsibility for recording notes during meetings and posting those notes on blackboard (include in your final report). All of these documents will be used in the final presentations.

Major Concepts

Project Planning (Gantt, deployment, CPM, budgets), time management skills, running team meetings, developing and assessing a development plan. Cad modeling, communicating technical information, iterative design for optimization, non-unique solutions, simulation, modeling and design realization.

Sequence of Events

- Prior teams robot passes by your robot while dropping off the part on your platform
- Your robot uses sensors to note the arrival and departure of the prior team's robot.
    - This is what activates your robot to begin.
- Your robot picks up the part from your platform
- Your robot carries part to next team's platform and drops it off.
- Your robot returns to its home position

Robotic Project Generic Layout