Integrating Entrepreneurial-minded Learning in Electronic Design Course

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Abstract

In recent years, more universities and faculty are engaged in incorporating entrepreneurial minded learning (EML) into the engineering curriculum. However, it is not easy for students to build up entrepreneurial skills within one course or a couple of courses in an already crowded engineering program. The College of Engineering (CoE) decided to embed entrepreneurial skills in engineering learning activities for a number of courses throughout the program curriculum, requiring an efficient and integrated process. By incorporating EML in different course sequences such as circuits, electronic design, and communication sequences, students will have the opportunity to develop and build up their entrepreneurial mindset.

The paper reviews the CoE's experience and preliminary evaluation results of integrating EML in our junior level course EE375 Electronic Design I. EE375 is the first electronics course of a three-course electronics design sequence. The course covers circuits design using diodes and transistors with several laboratory experiments.

This lab modification is part of a curriculum-wide effort to integrate EML to different course sequences. Students will be repeatedly exposed to entrepreneurship skills when applying them to their capstone design as well in the other course sequences.

Introduction

Engineers need to solve challenging, complex real world problems. In the article "Engineering the future ", the authors stated that training engineers to take on the challenges of the future and solve complex real problems are the most important contributions that colleges and universities make to advance the human condition [1]. Students need help to become master learners with the outcome-oriented mindset necessary to bring solutions to life.

In recent years, more universities and faculty are engaged in incorporating entrepreneurial minded learning (EML) into the engineering curriculum. Even though not every student will become an entrepreneur after they graduate, having an entrepreneurial mindset will help them become creative and valuable engineers. "EML is not about start-ups, it is about thinking creatively and creating value for society" [2]. However, it is not easy for students to build up entrepreneurial skills within one course or a couple of courses in an already crowded engineering program. The College of Engineering (CoE) at Colorado Technical University (CTU) decided to embed entrepreneurial skills in engineering learning activities for a number of courses throughout the program curriculum, requiring an efficient and integrated process. By incorporating EML in different course sequences such as circuits, electronic design, and communication sequences, students will have the opportunity to develop and build up their entrepreneurial mindset.

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“The three Cs: Curiosity, Connections, and Creating Value [3]” found in the KEEN framework are added as course outcomes. CoE included EML activities into the existing problem-based learning (PBL) laboratory projects. For example, the projects help students investigate the market and assess policy and regulatory issues. The paper will provide preliminary results from these projects combining both technical skills and elements of the entrepreneurial mindset.

This lab modification is part of a curriculum-wide effort to integrate EML to different course sequences. Students will be repeatedly exposed to entrepreneurial skills when applying them to their capstone design as well in the other course sequences.

CoE’s a long-term vision is to graduate students who have visionary leadership to create value and innovative solutions not only for themselves but also for their employers and for the benefit of society. CoE also intends to address the ABET question, paraphrased as: where to do you see your graduates three to five years beyond graduation?

The authors of this paper attended an “Innovating Curriculum with Entrepreneurial (ICE)” Workshop on 9-12 August 2017 in Denver, CO. The workshop was held in collaboration with the Kern Family Foundation and Lawrence Technological University. The main goal of the workshop is to promote student engagement in “the three Cs: Curiosity, Connections, and Creating Value” [3]. Kern Engineering Entrepreneurship Network (KEEN) published the framework at their website as shown in figure 1. The entrepreneurial mindset plus engineering skillset has been used to develop educational outcomes for several engineering courses.

Following the experience from the ICE workshop, the authors began to embed their proposed EML modules in several courses for strategic planning purposes starting in September 2017 for the fall 2017 quarter. EE375 Electronic Design I is one course among them.

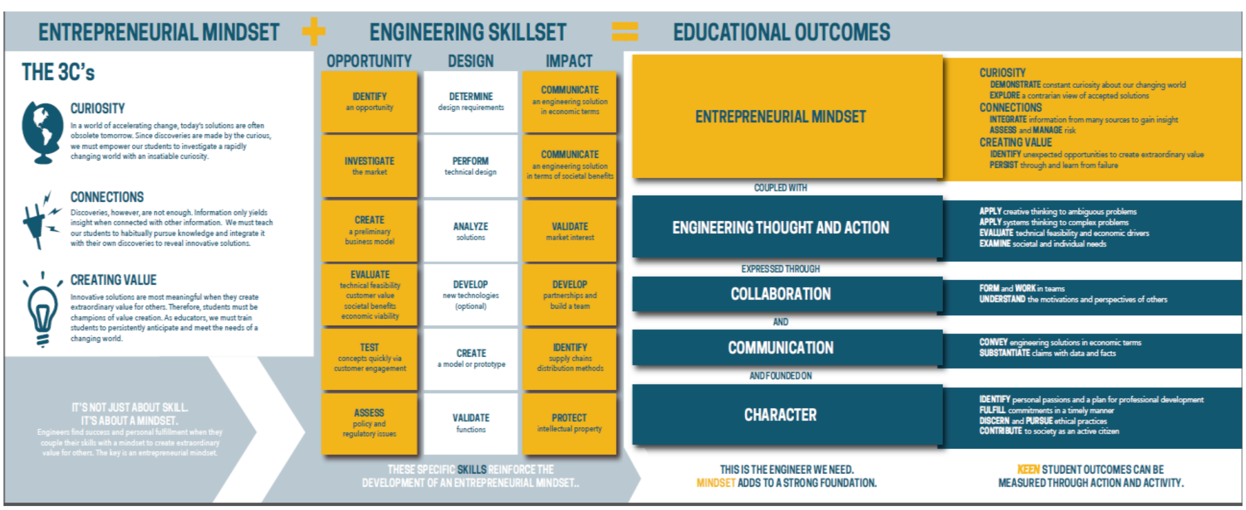


Figure 1. KEEN the Framework [4]

Literature Review of Entrepreneurial Minded Learning (EML) in Engineering Education

Kern Engineering Entrepreneurship Network (KEEN) lists the following title at their website: "Engineers with an Entrepreneurial Mindset Transform the World". Engineers equipped with an entrepreneurial mindset will understand the bigger picture, recognize opportunities, evaluate markets, and learn from mistakes to create value for themselves, for their employers and for society [5].

In the past, a curriculum of entrepreneurship education was most likely be found in business schools. With the rapid changes in the world and the globalization in the engineering area, more higher-education institutions worldwide saw the benefits of adopting the entrepreneurial skills into their engineering curriculum. According to Byers, "…beyond technical expertise, today's engineers must possess an entrepreneurial mindset in order to be the innovators of tomorrow." [6]

More and more universities in US are trying to incorporate EML into students' learning. Some universities have their own entrepreneurship center. For example, MIT has several departments, labs, centers, and over 40 student clubs and initiatives to foster entrepreneurship and innovation. Their educational efforts in this area resulted in having an impressive impact at local, regional, and global levels. "A 2015 report suggested that 30,000 companies founded by MIT alumni were active as of 2014, employing 4.6 million people and producing annual revenues of $1.9 trillion, equivalent to the world's 10th largest economy." [7] In addition, there is an entrepreneurship center in the Stanford's School of Engineering. The Stanford Technology Ventures Program (STVP) targets to accelerate entrepreneurship education at their university and around the world [8]. Santa Clara University has an aggressive extracurricular program which complements elements of the EML program. Each quarter, they have activities including seminars, lunch with an entrepreneur events, business and law primer presentations. One highlight of this program is an EML challenge in which teams of students develop ideas based on opportunities they identify in order to validate a market and assess the creation of value. The winner is often offered a "contract" to produce the product for university purposes [9] .

Some schools integrated EML in their course projects. The authors of the paper "Entrepreneurial Mindset and the University Curriculum [10]" applied technology based dynamic live case study with color graphics animated computer simulation in their entrepreneurial course. The live case study involves multiple student visits to existing companies. Students construct a company supply chain under the professor's guidance. Bilen, et al suggested to provide students with multiple exposures to what it means to have an entrepreneurial mindset [11]. Chasaki described a seven-week mini-project "Cyber Crime Scene Investigation" they reserved in their new course for EML activity [12]. The author found that freshman year is a great time to introduce EML concepts. EML objectives are introduced at the beginning of the mini-project. Students form two groups "hackers" and the "defenders", and rotate roles during the term. Students need to understand what value their business idea brings to the table, and how it fits customer's need. Wang introduced how they incorporated entrepreneurial mindset materials in a 10-week open-ended design project in a first-year Introduction to Engineering Course at Arizona State University. Students list pain points that bother themselves or others, and select their design project. They used a decision matrix with criteria "societal importance, general interest, market need, engineering related problem, number of current solutions, and solution benefit" to help students identify opportunity [13].

Several universities developed detailed four-year plans to implement EML in their curriculum. Welker, et, al [2]summarized the classes with EML in the four-year civil engineering curriculum at Villanova University. University of New Haven created short, self-paced, e-learning modules into courses spanning all four years of all engineering and computer science programs. They used a flipped classroom instructional model to integrate the modules into courses [14].

Schools applied different technologies when adopting EML. Tabrizi [15] fostered an entrepreneurial mindset in "digital systems" class through a jigsaw-puzzle model. In each lab assignment. They provide students with some components or puzzle pieces as well as the user guide of a digital system. The main EML objectives are to "stimulate students' curiosity, instill a feeling of value creation in students, and encourage teamwork, collaboration, and connection." Hoffman [16] introduced how they applied an entrepreneurial approach to a senior design course. In order to simulate the workplace, the entire design class functions as a startup company addressing an instructor generated problem for development of a new product. The University of Florida College Of Engineering offers an entrepreneurship course which mimics the real world experiences of enterprise formation and growth in an academic environment [17].

Universities outside the U.S. also noticed the importance of building an entrepreneurial mindset in their higher education systems. In a paper from Romania, the author mentioned the worry about the country's scores in terms of innovation capability. They are trying to find solutions from promoting technological entrepreneurship through sustainable engineering education. The paper summarized the top 10 technical and personal qualities of an ideal entrepreneurial engineer. These 10 qualities are: "analytical skills, rigor, communication skills, creativity, logical skills, technical knowledge, economic knowledge, managerial knowledge, reliability and integrity" [18] . There has been a growing concern in Malaysia that the technical students prefer to become job seekers and to be employed rather than job creators. The Ministry of Education aspires to instill an entrepreneurial mindset throughout Malaysia's higher education system [19].

Integrating Entrepreneurial Minded Learning in Our Electronic Design Course

The challenge of integrating EML in engineering curriculum is how to add the EML activities without additional workload to the currently packed curriculum. Instead of developing several courses in entrepreneurship, CoE plans to integrate EML in numerous engineering courses. Each course will have elements of the entrepreneurial minded elements to help students grow with "the three Cs". Incorporating EML in different course sequences such as analog and digital circuits, electronic design, and communication sequences will provide students an opportunity to develop and build up an entrepreneurial mindset.

In CoE's junior-level course EE375 Electronic Design I, EML objectives were incorporated in the course. A discussion will be given on CoE's experience and provide preliminary evaluation results when integrating EML. EE375 is the first electronics course of a three-course sequence in electronic design. The course covers diodes circuits design and bipolar junction transistor circuits design. The laboratory experiments included KEEN's 3Cs to develop the entrepreneurial mindset. Entrepreneurial elements were added to the labs to help students focus their attention on investigating the market and assessing policy and regulatory issues.

Students conduct laboratorial experiments in teams, usually in small teams of two or three students. For fall 2017 quarter, EE 375 had only six students. Two students worked in one team for the first four labs and three students worked together for lab 5. Each team was required to provide short presentations for each lab. The presentations about the lab and EML activities were discussed as a group. This allows the students to collaborate and understand the perspectives of others.

A description of the EML labs are discussed followed with preliminary students' survey results from fall 2017 quarter are summarized and analyzed next.

Embedding EML in Existing EE375 Labs

EE375 originally came with five lab projects. During the fall of 2017, the authors started to modify four out of the original five labs in order to add the entrepreneurial elements. The EML objectives were taken directly from the KEEN framework. The modified labs modules are described below.

Lab 1 Signal Measurements. The original lab1 guides students to go through several standard measurements and procedures used in electronics laboratories. The objective of the lab is to familiarize students with electronics lab measurements equipment. To embed entrepreneurial elements, one short section is added to the lab manual as shown below: "EML objective:

Integrate information from many sources to gain insight. Section 2. As an electrical or computer engineering student, do you want to have affordable electronics lab at home? During this signal measurements lab experiment, you reviewed the lab equipment we have in our engineering lab. After completing the lab, please figure out what equipment you will need for setting up a home lab. Please include an estimated budget (vendors, price for equipment and parts)."

Lab 2 DC Power Supply Design. The original lab manual guide students to design an AC to DC power supply step by step. Original objectives of this lab include:

- To design and implement a DC power supply
- Verify the performance of DC power supply built with discrete diodes and integrated bridge rectifier
- Design, implement and verify an RC filter performance

- Measure the output ripple in a power supply
- Design and study the performance of the Zener regulated DC power supply

To build an entrepreneurial mindset, the following EML objectives are added:

- Demonstrate constant curiosity about our changing world
- Integrate information from many sources to gain insight
- Identify unexpected opportunities to create extraordinary value
- Persist through and learn from failure
- Assess policy and regulatory issues

The original lab manual description tells students to use transformer with an output of 12.6Vrms as an input to a full-wave rectifier bridge. The students are asked to design a filter to limit the ripple to within 10% of the output voltage. The load resistor ranges from 1K to 10K. Finally, students will use Zener diodes to regulate the DC output.

Figure 2. Panel of a Power Supply

The modified lab with EML can now be described as follows:

One customer requires the university team to design a 10V DC power supply to power the customer's special electronics device. The input resistance of the special electronics device is between 1k and 10k. The customer has already bought a transformer with an output of 12.6Vrms, and a 1N4740 10V Zener diode. The customer hopes that the design will use his components to reduce the budget. The ripple needs to be within 10% of the output voltage.

Since the normal lab power supply are too bulky and expensive, the customer wants to have a power supply that is cheap, reliable, efficient and small. The customer requires the design team to provide a budget and follow policy and regulations. For example, consider what all the symbols mean on the battery panel found in Figure 2.

Two students will be in each team. The customer need the teams to complete the project within two weeks.

The project has design suggestions found in the problem description given as:

- Each design team need to consult with customer and write the requirements specifications of the design
- Be aware of regulation issues
- Determine the design deliverable
- Research different sources when you conduct the design in order to provide alternative designs
- Suggest using the top-down and bottom-up "V" model to conduct the design process. The system might be divided to two subsystems: "Bridge Rectifier and Filter" and "Regulated DC Power Supply"

- In order to finish the design and test on time, each team need to decide what pre-lab work your team need to finish before coming to class
- Compare your design with commercial DC power supplies. Find the requirements and design differences

***Lab 4 BJT Amplifier*.** The title of this lab changed to "Room Temperature Controller for Planting Cool-Season Vegetables". The original project tells students to design a BJT Amplifier with a gain of 10, and input resistance need to be at least 10Kohms.

Here are the original objectives:

- Design an amplifier using a BJT.
- Simulate, debug and verify in laboratory experiment the characteristics of the transistor amplifier.
- Determine the gain, the input resistance, output resistance, and the (frequency) bandwidth of the amplifier, by simulation and by measurement.

For this lab experiment, here are the EML objectives:

- Demonstrate constant curiosity about our changing world.
- Integrate information from many sources to gain insight.
- Identify unexpected opportunities to create extraordinary value.
- Persist through and learn from failure.

The problem statement is given as follows:

One of our local farms wants to plant cool-season vegetables in its indoor garden. "Cool-season vegetables grow best when temperatures range between 40 degrees Fahrenheit and 75 degrees Fahrenheit." [20] The project needs to have room temperature controllers to turn on their existing cooking fans in room. Temperature sensors such as the TMP35/TMP36/TMP37 could be used to measure temperature and output a voltage. An Arduino microcontroller can be used to compare the signal to preset thresholds, and produce an on/off voltage signal to control the cooling fan. The problem is that the output voltage' range from the temperature sensor and the input voltage range of Arduino do not match. The EE375 teams need to finish the design and solve the mismatching problem.

The design teams need to consider how to match the requirements specifications? How could you improve the design of this amplifier? Will your design benefit other local farms?

By stating the problem to satisfy customer needs, students must to figure out the system requirements themselves by integrating information from different sources. And then design and evaluate the engineering solution to meet customer requirements.

***Lab 5 CMOS and BJT*.** The original lab was design to help students understand the performance and characteristics of CMOS and BJT technology. The title of this lab is changed to "which technology could be used in Artificial Intelligence, BJT or CMOS?"

To build an entrepreneurial mindset, the following EML objectives are added:

- Demonstrate constant curiosity about our changing world.
- Integrate information from many sources to gain insight.
- Identify unexpected opportunities to create extraordinary value.
- Persist through and learn from failure.

The authors added the following content in the project description:

Artificial Intelligence (AI) will change the world. And it should continue to change the world. Please watch or read the following content about 'Deep Learning and Artificial Intelligence':

a. Artificial Intelligence
https://www.youtube.com/watch?v=5J5bDQHQR1g
b. Deep Learning SIMPLIFIED: The Series Intro – Ep. 1
https://www.youtube.com/watch?v=b99UVkWzYTQ
c. Deep Learning SIMPLIFIED: The Series Intro – Ep. 2
https://www.youtube.com/watch?v=P2HPcj8lRJE&index=2&list=PLjJh1vlSEYgvGod9wWiydumYl8hOXixNu
d. Google and NASA's Quantum Artificial Intelligence Lab
https://www.youtube.com/watch?v=CMdHDHEuOUE

Complementary Metal Oxide Semiconductor (CMOS) and Transistor–transistor logic (TTL) are widely used in IC digital technologies. Each student will need to compare those two technologies, and determine which one should be used in AI?

This lab is in general an open-ended and what the authors are looking for is the EML thinking and technical skills in justifying their choice. In other words, open-ended is meant to be that there is no 'school solution'.

The description of the lab also includes the following background information for the students:

The digital applications of CMOS can be found in a wide range of consumer electronics, from personal computers to sophisticated measurement instrumentation. A small scale integration CMOS quad 2-input NAND Gate is investigated in this lab, and compared to a BJT NAND.

In addition, here are some suggestions given to the students:

- Compare the NAND gate in **CD4011B** and TTL NAND gate in **74LS00**. Consider why we care about NAND gate?
- Simulate, measure and verify in laboratory experiment the function of the CMOS/TTL NAND Gates. Validate the compliance with the manufacturer's specifications, specifically the **gate input to output propagation delay** as a function of load capacitance. Compare the specification with TTL NAND gate performance.
- Which technology could be used in Artificial Intelligence? Why?

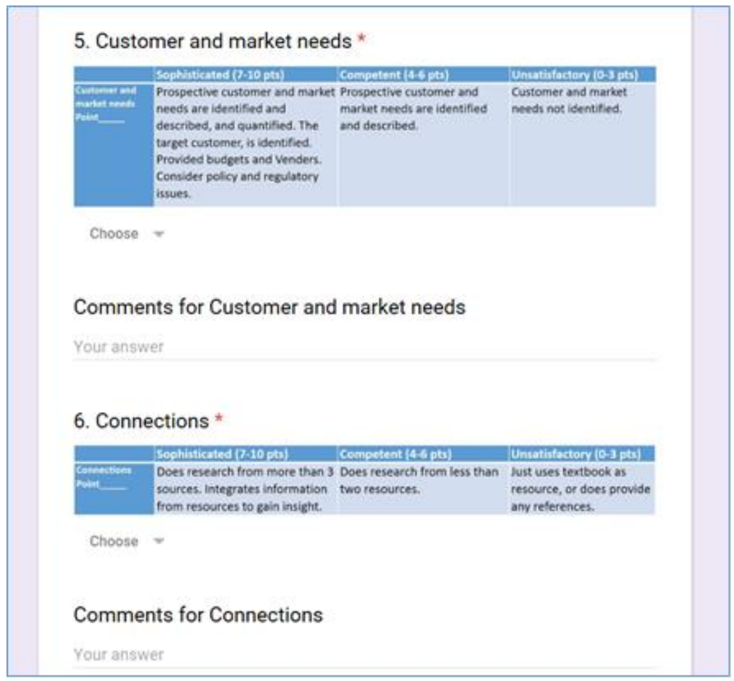
Analysis of Labs Evaluations and Students Survey Results

In fall 2017 quarter, the survey involved six students. Evaluation rubrics were created to include the newly added EML elements: "Customer and Market needs", "Connections", and "Creating Value". Since students learn more by doing, the authors wanted to help students become more aware of the importance of having both technical skills and an entrepreneurial mindset by doing peer and self-evaluations.

Students uploaded their team's reports in the discussion board in the university's portal. After the short presentations from each team and the discussion among the teams, each student read lab reports from all the teams. Then, they provide feedback including assessment scores and comments through Google forms. The assessment rubrics are shown in Table 1 in the Appendix.

To minimize the instructor's workload when consolidating the data received from students, the authors used Google Forms. An example of evaluation form in Google form is shown in figure 3. EE375 Fall 2017 has three teams labeled as team 1, 2, and 3. The evaluation for Team 3 is summarized in Table 2 in the Appendix as an example. The instructors provided the summary as feedback to the team.

The figures 4a, 4b and 4c summarized the evaluation scores of Lab 2 and Lab 4 for the three teams. In these figures, the combined peer and self-evaluation scores show that the students are aware of system requirements, customer need, making connections with their research on marketing, as well as assessing policies and regulations.


5. Customer and market needs *

	Sophisticated (7-10 pts)	Competent (4-6 pts)	Unsatisfactory (0-3 pts)
Customer and market needs Point_____	Prospective customer and market needs are identified and described, and quantified. The target customer, is identified. Provided budgets and Venders. Consider policy and regulatory issues.	Prospective customer and market needs are identified and described.	Customer and market needs not identified.

Choose

Comments for Customer and market needs

Your answer

6. Connections *

	Sophisticated (7-10 pts)	Competent (4-6 pts)	Unsatisfactory (0-3 pts)
Connections Point_____	Does research from more than 3 sources. Integrates information from resources to gain insight.	Does research from less than two resources.	Just uses textbook as resource, or does provide any references.

Choose

Comments for Connections

Your answer

Figure 3. An example of evaluation in Google form.

After comparing the evaluation scores of Labs 2 and 4, the preliminary results show that students' scores improved in "Organization", "Citing", "Market Need", "Connections" sections.

The scores for the other two sections', design solutions and creating value, decreased from Lab 2 to Lab 4. The average class evaluation scores for Labs 2 and 4 are shown in figure 5. The trend of lower scores in creating value from Lab 2 to Lab 4, can be explained by the more complex design of interfacing a temperature sensor and Arduino board since the sensor is producing both dc and ac signals. It was not clear to the students that they need to only amplify the ac portion of the signal. The authors noted that for the dc decoupling capacitor needs to operate at a higher frequency to act as a short and realistically the temperature sensor outputs do not change that fast, say at 1000 Hz. The authors will need to make the Lab 4 more realistic to the students or emphasize that only the ac portion of the sensor outputs need to be amplified.

Since this was the first time that the new lab modules with EML activities were used in EE375 course, the authors required students to do a peer and self-evaluation for Labs 2 and 4. The intent of using peer and self-evaluation is to help students become aware of technical and EML objectives. In addition, students help each other improve by providing their evaluations and feedback as well as understanding each other's perspectives. Since this sample pool is too small, the authors need to collect more data from the course in the following quarters.

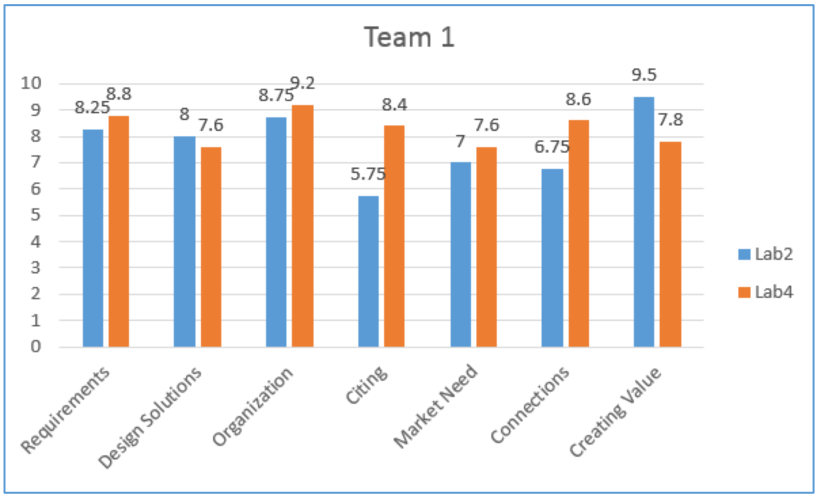


Figure 4a. Evaluation Scores of Lab2 and Lab4 for Team 1, Fall 2017

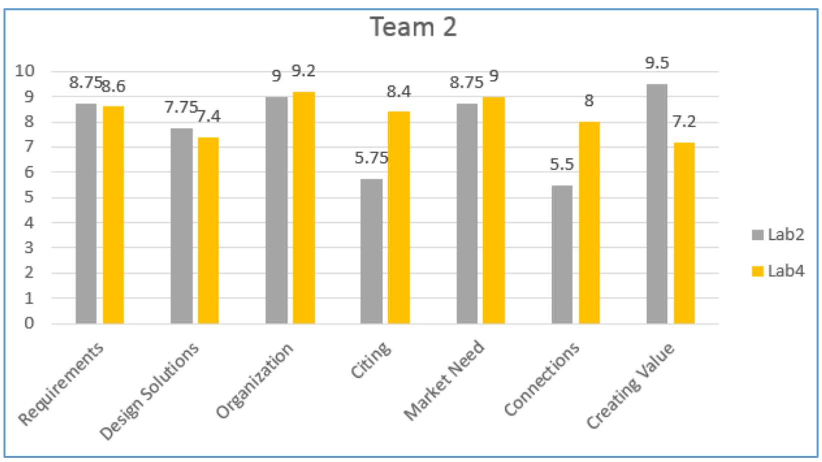


Figure 4b. Evaluation Scores of Lab2 and Lab4 for Team 2, Fall 2017

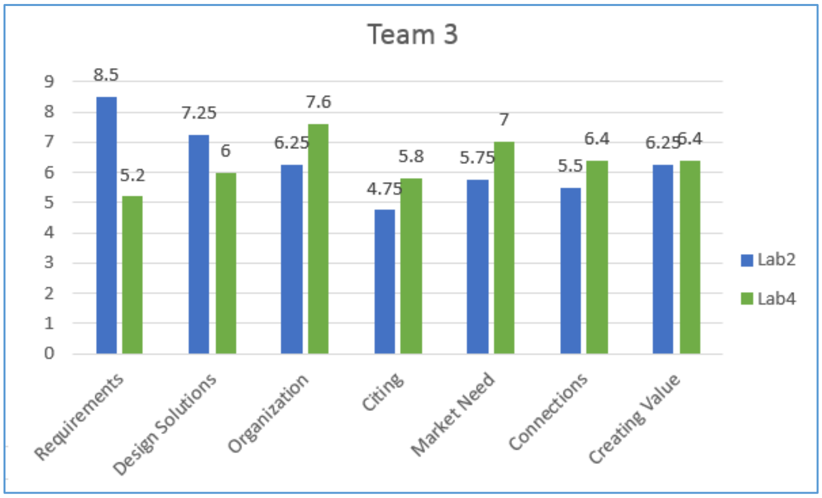


Figure 4c. Evaluation Scores of Lab2 and Lab4 for Team 3, Fall 2017

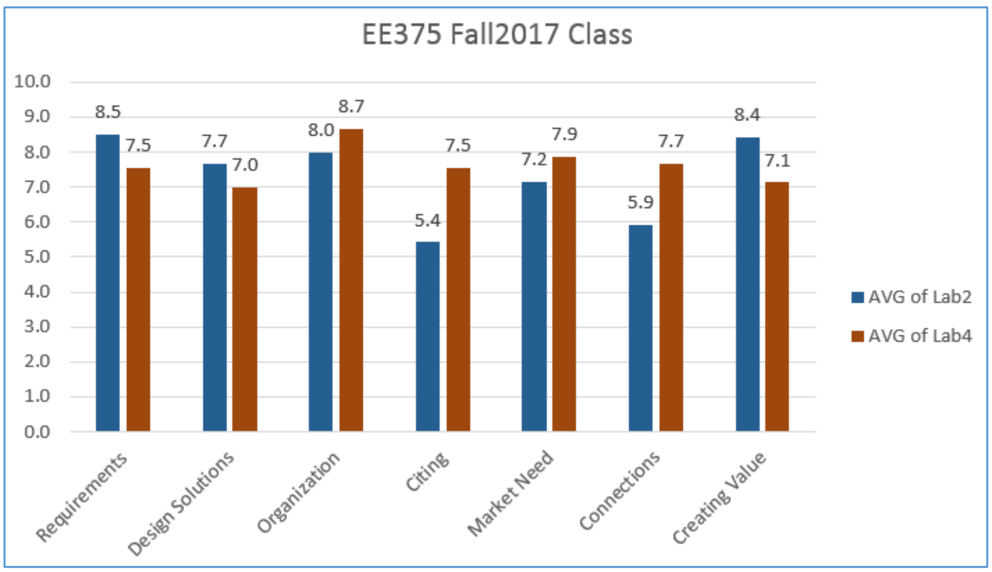


Figure 5. Average class scores for Lab2 and Lab4.

The survey about EML modules were given to students at the end of the quarter. Five out of six students did the survey. Table 3 in the Appendix listed the topics and questions of the survey. Average students' survey scores are listed in Figure 6. Students' survey comments are summarized in Table 4 in the Appendix.

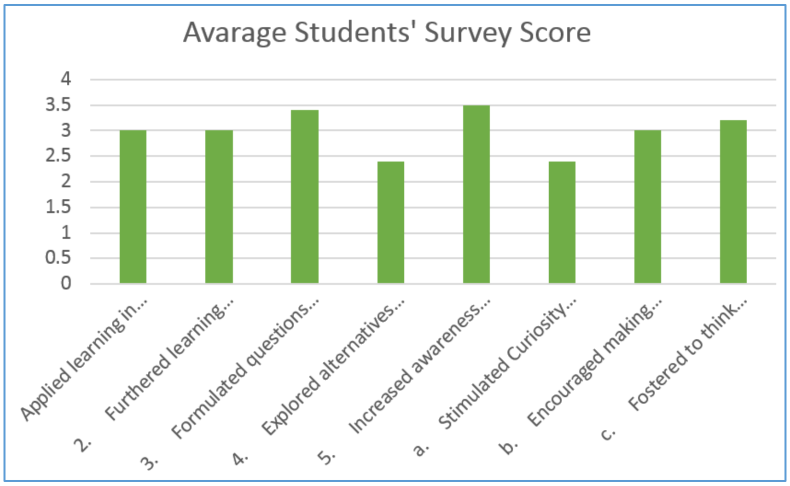


Figure 6. Average Students' Survey Score, fall 2017

Based on comments of Table 4, students provided positive feedback to the EML components. However, one student commented that more time is needed to think about either the entrepreneurial skills or provide more guidance in the design process. In figure 6, their survey scores for all the questions are above neutral with most leaning toward "agree". The EML elements in the labs help students become aware of the importance of KEEN's 3Cs and encouraged them to design with an entrepreneurial mindset.

Conclusion and Future Work

The electronic labs for EE375 were modified to integrate EML elements. Based on student feedback, the new labs helped students become more aware of the entrepreneurial mindset and KEEN's 3Cs: curiosity, connections and creating value. Student feedback on the integrated EML lab modules are in general positive. Integrating the EML in the electronic design course helped engage students: (1) to combine information from different sources, (2) to become aware of the importance of doing market research, (3) to understand customer requirements, and (4) to consider policy and regulations in their engineering design solutions. The students began to form an entrepreneurial mindset during the design process when going through the series of labs.

Fall 2017 was the first quarter to apply the newly developed EML lab modules. The data sample is small and the results are preliminary. The lab modules still need to be revised to help students improve on developing their entrepreneurial skills. For example, Lab 4 need to be more realistic to the students or emphasize that only the ac portion of the sensor outputs need to be amplified. The authors will continue integrating EML in other engineering course sequences, including subjects in circuit design, communication systems, and digital electronics. The capstone courses in undergraduate curriculum at CTU have elements of systems thinking but the KEEN framework provides an important reference in developing more entrepreneurial skills for students.

Since the authors have each taught over 40 courses in the BSEE, BSCE, MSEE, MSCE and MSSE (System Engineering) programs, these courses will have numerous elements of KEEN's entrepreneurial skills as a strategic plan during the next several years. The authors intend to push students toward having an entrepreneurial mindset. With more EML activities embedded in the courses, the students' mindset will become a habit.

For example, the authors have introduced the KEEN framework in several undergraduate and graduate courses during the Fall 2017 and Winter 2018 quarters. These courses include the following:

- Signals and Systems
- Communications Systems II
- Product Design I
- Impact of Global Issues on Design
- Communication System Design
- Computer Engineering Capstone
- Digital Signal Processing
- Circuit Analysis I

The CoE intends to cooperate with other universities in the KEEN network to develop more engineering activities having EML, share information and resources, and grow together while incrementally changing the curriculum.

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Appendix: Tables

	Sophisticated (7-10 pts)	Competent (4-6 pts)	Unsatisfactory (0-3 pts)
Requirements Specifications	All customer requirements and associated engineering requirements are included. Requirements do not use ambiguous terminology.	Some design requirements do not have engineering satisfactory requirements associated. Ambiguous terminology is used in engineering requirements. e.g. words like big, better, nice, good, etc.	Design requirements are not explained. Design Requirements are not formatted as a list. Requirements are mostly vague and incomplete. Requirements do little to actually describe what is needed from the project.
Design Solutions	Alternative possible solutions are described fully and completely. Several of the designs are feasible and could potentially solve the design problem. Circuits Testing show all the requirements are meet.	Alternative possible solutions are described, but the reasoning behind selecting or deselecting them is not clear or could use elaboration. Circuits Testing show portion of the requirements are meet.	No final design solution is suggested, or reason behind decisions is not presented. No other possible solutions are discussed.
Organization	Authors' purpose is clear. Information is logical. Introduction is clearly presented. Conclusion is presented and defended.	Authors' purpose is partially clear. Most information is logically provided. Conclusion is presented, but is not defended.	An identifiable introduction and/or conclusion have not been provided.
Citing Sources	All borrowed material has been acknowledged with specific in-text documentation. Contains a bibliography that lists all sources cited. References and bibliography adhere to IEEE or APA style guidelines.	Contains a bibliography that lists sources. Not citation provided in the PPT or report.	No references list provided.
Customer and market needs	Prospective customer and market needs are identified and described, and quantified. The target customer, is identified. [1] Provided budgets and Venders. Consider policy and regulatory issues.	Prospective customer and market needs are identified and described.	Customer and market needs not identified.
Connections	Does research from more than 3 sources. Integrates information from resources to gain insight.	Does research from less than two resources.	Just uses textbook as resource, or does provide any references.
Creating Value	Persists through and learns from failure. Record the failure in the design process, and learn from it to improve the design.	Identified, and recorded the failure, but not improvement provided.	Does not record the failure.

Table 1. Lab Peer and Self-Evaluation Rubric

Evaluate for Team 3 Lab4	Average	Comments
1.Requirements Specifications	5.2	Design was not followed through with. Suggested an alternate design; The requirements are not clearly stated that came in from the customer. Didn't quite meet all requirements
2. Design Solutions	6	Coupling capacitors to balance out the gain; Didn't fully understand the input device.; Alternate design described, did not see any circuits testing; It was in the report but wasn't really elaborated on.; Could use elaboration
3. Organization	7.6	Information was well presented, but no conclusion; It was a good presentation, but if there were more material in the report then it may have been easier to understand.; Good job
4. Citing Sources	5.8	Sources were mentioned; The was no formatted sources.; Good
5. Customer and market needs	7	The needs of the customer were talked about but weren't detailed in the report very well.; Could elaborate more
6. Connections	6.4	It was stated that only one source was used based on the average price of the parts used in the circuit. ; Good
7. Creating Value	6.4	Recommended alternate design rather than a solution to their design problem; The lab partners mentioned difficulties with the circuit based on not including any capacitors and adding extra resistors. ; No improvement provided
Total	44.4	
%	63.4	

Table 2. Evaluation Feedback Summary of lab 4 for Team 3 in Fall 2017 Quarter

Survey on the Entrepreneurial-Minded Learning (EML) Projects for
EE 375 – ELECTRONIC DESIGN I

Given the EML/thinking activities in lab projects and in comparison, to other courses, the EML course activities emphasized the following?

Topics/Questions	Strongly Disagree 0	Disagree 1	Neutral 2	Agree 3	Strongly Agree 4
1. Applied learning in new contexts					
Comments:					
2. Furthered learning beyond the course content curriculum					
Comments:					
3. Formulated questions and generated own inquiries					
Comments:					
4. Explored alternatives or encouraged forming contrarian views of accepted solutions					
Comments:					
5. ***Increased awareness of the Entrepreneurial Mindset along with the Technical Skillset***					
a. Stimulated ***Curiosity*** about the changing world					
b. Encouraged *making* ***Connections*** to integrate knowledge to everyday life					
c. Fostered to think about ***Creating Value*** for yourself or society					
Comments:					
6. Suggestions for Improvements or other comments:					

Table 3. EML Survey Table

Topics/Questions
1. Applied learning in new contexts
Comments:
2. Furthered learning beyond the course content curriculum
Comments: Having the labs related to outside projects (temp sensor, power source) made some things make more sense than just solving problems
3. Formulated questions and generated own inquiries
Comments:
4. Explored alternatives or encouraged forming contrarian views of accepted solutions
Comments: The labs did not have one correct answer on how to design it. Learning most of the design up to us. Let us have to think and reason more.
5. ***Increased awareness of the Entrepreneurial Mindset along with the Technical Skillset***
a. Stimulated ***Curiosity*** about the changing world
b. Encouraged *making* ***Connections*** to integrate knowledge to everyday life
c. Fostered to think about ***Creating Value*** for yourself or society
Comments: The more I learn and become able to use the course material, the more DIY projects I think up for my house.
Suggestions for Improvements or other comments:
Broader range design labs. I really like the concept behind the Entrepreneurial Labs. It Helps take the student to a newer level of underrating on what they're doing because it's not just a bunch of calculation, but putting a physical Mindset in motion.

Table 4. Survey Comments, fall 2017