Introducing a Business Acumen into an Engineering Curriculum

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Abstract

The Electrical and Computer Engineering (ECE) department at the Western New England University began an effort to integrate business acumen into the ECE curriculum. The effort started in academic year 2011 – 2012 with two required lab-based ECE courses and one lecture-based design elective course. For academic year 2012 – 2013 the effort has been expanded to include four additional lecture-based courses.

Students enrolled in the Junior EE Lab sequence, EE Lab I (EE 319) and EE Lab IIa (EE 323), are required to develop a budget for each lab experiment. The budget is an estimate on the costs associated with performing the lab experiment. Students are given table that lists various costs such labor rates, use of the lab space, and an overhead rate. The creation of the budget is a pre-lab task. A post-lab task that is included in the lab report a cost report. The cost report details the actual cost of performing the experiment and comparing the actual costs with the predicted costs.

The lecture-based courses all have at least one design project. Modifications were made to the current design project to include the components that would typically be found in a business setting (for example, cost proposals). Students are required to bid on the project. Students must submit a final report which includes the cost report – including an analysis of the bid cost versus the actual cost. The professor assumes a variety of roles for the projects such as customer, VP of Engineering, and Senior Engineer.

The paper will discuss the learning objectives, the outcomes, and the assessment process.

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Introduction

This paper presents an approach for integrating business acumen into an engineering curriculum. The effort started in the fall of 2011 with a single junior-level lab-based course and has been expanded to one more lab-based course and several lecture-based courses. The changes have been well-received by students.

To accomplish this aim, the paper is organized as follows. First the background on the impetus for this change is given. Next, the curricular changes are detailed. Following this, the assessment process is discussed, followed by a brief conclusion.

Background

In 2011, the College of Engineering at the Western New England University won a grant from the Kern Entrepreneurship Education Network (KEEN). The stated mission of the KEEN program is[1]:

> … *The creation of programs that develop technical leaders with strong skills and an entrepreneurial mindset in undergraduate engineering programs at select private U.S. colleges and universities.*

The Kern Entrepreneurship Education Network (KEEN) provides resources to private colleges and universities to introduce the principles of entrepreneurship into the curriculum.
A student encountering the KEEN program should be able to:

1. Effectively collaborate in a team setting
2. Apply critical & creative thinking to ambiguous problems
3. Construct & effectively communicate a customer "appropriate value proposition"
4. Persist through and learn from failure
5. Effectively manage projects through appropriate commercialization or final delivery process
6. Demonstrate voluntary social responsibility
7. Relate personal liberties and free enterprise to entrepreneurship

With the KEEN grant award, the Electrical and Computer Engineering (ECE) department began an effort to integrate business acumen into two ECE courses. The effort started in academic year 2011 – 2012 with two required lab-based ECE courses and one lecture-based design elective course:

- EE Lab I (EE 319) - a junior-level two-hour lab course
- EE Lab IIa (EE 323) - a junior-level one-hour lab course
- Microwave Engineering (EE 414) – an elective lecture-based course

For academic year 2012 – 2013 the effort has been expanded to include four additional lecture-based courses:

- Fields & Waves (EE 314) - a junior-level required course
- Microelectronics II (EE 320) - a junior-level required course
- Antenna Design (EE 457) – an elective lecture-based course
- RF & Microwave Active Circuit Design (EE 456) - an elective lecture-based course

Course Design

The following discusses how business acumen was integrated into an engineering curriculum. This section is divided into two subsections; lab-based courses and lecture-based courses.

Lab Based Courses:

In industry individuals work with multiple groups on multiple projects simultaneously. Juggling multiple priorities for a myriad of projects can be an overwhelming situation for a new engineer. To expose students to this situation a schedule has been created where at any given time a student will be working with 3 different groups on 3 different labs. Labs are performed weekly with the report due 2 weeks after the completion of the lab. To simulate an industry environment the following system for combining groups for lab reports has been created.

Students are assigned a permanent lab partner for the semester; all experiments are completed with this lab partner. For the preparation of each lab report the lab groups are paired with another lab group to form a team of 4 students. The teams of four are changed with each new lab assignment. See Table 1 for an example.

Table 1 A typical group's (Group 01) activities for the third week of the semester.

Team	Tasks
Group 01 Group 02	Completed Lab 1 two weeks prior. Finishing the lab report for Lab 1.
Group 01 Group 03	Completed Lab 2 one week prior. Commencing the writing and data analysis for Lab 2's report.
Group 01 Group 04	Creating a cost estimate for Lab 3.

Lab Tasks:

1. The day before the actual lab, the team (4 students) meets to complete the pre-lab activity. The pre-lab is the creation of a cost estimate (budget) to carry out the experiment. The estimate must include all materials, lab usage costs and the cost of the time required to prepare the lab report. Students are given a table that lists various costs such as labor rates, use of the lab space, and an overhead rate to assist them with the completion of their estimate (Table 2). Please note that some of the costs in Table 2 are not necessarily realistic costs. A software package such as MATLAB would not be billed at $25/hr. The cost of components such as resistors, capacitors, etc is assumed to be included in the cost for the Jr. Lab. In several experiments, however, the transistor arrays (ALD1105, ALD1106 or ALD1107) are used. For budgeting purposes these transistor arrays are assumed to cost $100/chip – the actual cost is only $1 per chip, but in order to show the students that this was a special component it was not included in the base lab cost. This was done so that students will get a feel for the expense of some components and be aware that there are costs associated with items.

Table 2 EE Lab I and EE Lab IIa cost table.

	Rate	Type of Cost
Jr. Engineer (Student)	$ 37.50 /hr	Direct
Sr. Engineer (Professor)	$ 67.50 /hr	Direct
Overhead Rate	50 %	Indirect
Jr. Lab	$ 250.00 /hr	Direct
SPICE	$ 100.00 /hr	Direct
MATLAB	$ 25.00 /hr	Direct
ALD110X	$ 100.00 /chip	Direct

Students generally don't have a concept of the true cost associated with performing real engineering tasks. The students do recognize that their own salary is a cost. They do not, however, consider things such as overhead, computer usage costs, parts and materials, etc. Having students estimate the cost of the lab provides them with some idea of all of the costs associated with a project.

2. Each pair of students then performs the experiment.

3. After the completion of the lab, the team (4 students) meets to prepare a complete lab report. In addition to the traditional data analysis, the reports includes the cost report for the lab, which compares the actual cost of performing the experiment to their cost estimates as well as an analysis of estimated versus actual costs.

Lecture-Based Courses:

The previously mentioned lecture-based courses all have at least one design project. Most of the courses have three design projects.

Modifications were made to the current design project to include the components that would typically be found in a business setting (for example, cost proposals).

Students are required to bid on the project. For example, the project may be an internal R&D project or a commercial fixed-price contract. Once the bid is accepted the students are generally required to perform two design reviews (PDR and CDR). Students must submit a final report which includes the cost report – including an analysis of the bid cost versus the actual cost. The professor assumes a variety of roles for the projects such as customer, VP of Engineering, and Senior Engineer. An example from EE314 Fields & Waves is outlined below:

1. Create a company consisting of three students. Give your company a name.
2. Submit a proposal outlining your company's design approach. The type of contract to be awarded is a firm fixed-price contract. This proposal must be approved by the Vice President of Engineering before being sent out.
3. There will be two design reviews, a PDR and a CDR. You must schedule a time with the customer for each review. For budgeting purposes, you should assume that each review will take about 1 hour.
4. All designs should be reviewed by a senior engineer. For budgeting purposes, you should assume the review will take about 1 hour. All designs to be fabricated must be reviewed by a manufacturing and process engineer. For budgeting purposes, you should assume the review will take about 1 hour.
5. You must submit a final report. The report should detail how you verified your design. In addition, a cost report must be submitted.

The cost estimates, which appear below in Table 3, are provided to the students to ensure they are aware of the many costs associated with a design project. The students must account for not only their time, but also the time of others and all materials as well as overhead costs. If they are using outside contractors they must be aware of prevailing wage laws and budget accordingly. The costs also provide turn-around times so the

students are aware of the time it takes to build components and can design their project plan accordingly. The delay of shipment of even one component can have a drastic effect on the cost and delivery date of a project.

Table 3 EE 314 (Field & Waves) project cost table.

	Rate	Type of Cost
Jr. Engineer (Student)	$ 37.50 /hr	Direct
Senior Engineer	$ 67.50 /hr	Direct
VP Eng.	$ 100.00 /hr	Direct
M& P Engineer	$ 30.00 /hr	Direct
Technician	$ 17.50 /hr	Direct
Overhead Rate	50 %	Indirect
SMA Connectors	$ 100.00 /each	Direct
PCB Fabrication In House 4 Day Turnaround	2 Boards: $ 500.00 Additional Boards: $200.00 each	Direct
PCB Fabrication 2 Day Turnaround	2 Boards: $ 1000.00 Additional Boards: $250.00 each	Direct
Microwave Lab	$ 500.00 /hr	Direct
Ansoft Designer	$ 250.00 /hr	Direct
MATLAB	$ 25.00 /hr	Direct

Assessment

In the lab-based courses, one component of the lab report grade is the cost report. The cost report is graded on the pre-lab cost estimate, the actual costs, and the discussion on the differences in estimated and actual costs.

In the lecture-based courses, the design projects are used as an assessment tool. The students are assessed on the proposal, the design reviews, and the cost report. Each of these areas is graded using separate point values.

One of the first design projects assigned was a firm fixed-price contract. The students did account for all estimated costs for performing the design task and their actual costs were very close to the proposed costs. However, one of the lessons learned was that in general, students didn't include a profit for their work. Although students were instructed that the proposal was being submitted to the customer, they were unclear on how to build profit into their proposals. As a result, the following modification was made for firm fixed-price contracts the students are now instructed to read the section entitled "Margin Policy" in the document *Defense Department Profit and Contract Finance Policies and Their Effects on Contract and Contractor Performance*[2].

Conclusion

This paper presented an approach for integrating business acumen into an engineering curriculum. The effort started in the fall of 2011 with a single junior level lab-based course and has been expanded to one more lab-based course and several lecture-based courses. The effort has been extremely successful; the students are being exposed to some of the business aspects of being an engineer (budgeting and cost proposals.) In addition to the accounting oriented skills the students are placed in varying and an ever-changing work group which introduces them to the team-based approach utilized in most businesses today. Overall as a result of these changes the students from Western New England University will be better prepared for the work force.

References

[1] *Kern Family Foundation.* (2013). Retrieved from http://www.kffdn.org/default.asp?L1=InnovationPrograms&L2=KEEN

[2] Scot A. Arnold, Bruce R. Harmon, Karen W. Tyson, Kenton G. Fasana, Christopher S. Wait. (2009). *Defense Department Profit and Contract Finance Policies and Their Effects on Contract and Contractor Performance.* Alexandria, Virginia: Institute for Defense Analyses