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Inclusion of Entrepreneurially Minded Learning (EML) Modules in 2nd-Year Core Engineering Courses

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Abstract

Modules that focus on entrepreneurially minded learning (EML) were developed for inclusion in 2nd-year core engineering courses at Western New England University. The courses in which modules were implemented include Statics (ME 202) and Probability & Statistics (IE 212); these courses were selected to maximize coverage in the curriculum since all undergraduate engineering majors take one or both of these courses during their studies. The Statics module involved a case study focused on a historical engineering failure, allowing students to gain an understanding of why the structure failed and ways the design could be improved. The module in Probability & Statistics consisted of market research analysis that was used to make a data-driven decision on where to locate a new facility for a fictitious company. Results from pre- and post-activity surveys for these modules showed statistically significant changes in student-reported knowledge/ability regarding various EML skills, including importance of investigating the market (IE 212) and evaluating customer needs (ME 202). Additionally, student answers to free response questions indicate the modules were successful in challenging the students' perception of EML and the importance of EML skills.

Introduction

Recently, there has been significant interest in the inclusion of activities based on entrepreneurially minded learning (EML) in engineering courses.[1-3] The interest is due to a variety of factors, including feedback from employers that students with EML skills are more highly sought than those with strictly technical backgrounds.[1] Skills that have been identified as being important for an entrepreneurial mindset include effective communication, teamwork, customer awareness, learning through failure, and tolerance for ambiguity.[1] Since these skills are not typically cultivated in the traditional engineering curriculum, new EML-based activities that can be implemented in existing engineering courses are highly sought.

At Western New England University, we are focusing our new EML modules on 2nd-year core engineering courses, so as to maximize coverage in the curriculum while also complementing existing EML activities in 1st- and 4th- year courses (e.g,. Introduction to Engineering and Senior Design, respectively). Here, we describe EML modules that were developed for Statics (ME 202) and Probability & Statistics (IE 212). These courses were selected to maximize coverage in the curriculum since all undergraduate engineering majors take one or both of these courses during their studies.

Activity Details

IE 212

A take-home assignment was developed for implementation in IE 212 (Probability & Statistics). The activity involved having the students conduct market research analysis for different areas in the United States. The goal of the analysis was to determine the best region of the country to locate a new fabrication facility for producing alternative energy homes, using population growth rate from census data as the primary metric. The assignment was administered toward the end of the semester when students had developed knowledge of conducting statistical analyses such as t-tests and hypothesis testing. EML skills that were targeted for the module included the importance of investigating the market, opportunity identification, and evaluating customer needs.

ME 202

For ME 202 (Statics), a case study module was developed for implementation during two class periods. The case study focused on an engineering failure related to statics, specifically the Hyatt Regency Hotel Walkway Collapse. The idea behind the case study was that students will gain an understanding of why the structure failed through a reverse engineering process, and then determine the best way to improve it. The case study was completed in teams of 3-4. Target EML skills for the activity included the importance of clearly communicating designs, evaluating customer needs, and communication within a group and with the customer.

During the first class period of the module, the students travel back in time to the 1980's where they are engineers in Kansas City, Missouri, having a meeting with the management of the Crown Center Redevelopment Corporation (the course instructor, i.e. customer). In this initial meeting students are given a *Request for Proposal* outlining the overall objective and requirements of the design and debriefed on the recent tragedy. This debriefing provides students the details behind the history of the Hyatt Regency Hotel Walkway design, re-design, and collapse. This portion of the module is critical in that it not only prevents students from being able to use published resources as their own design, but also provides them the necessary background for their task. It then becomes the duty of the students to utilize this information to prevent future disasters.

The overall objective of this case study is for students to design and engineer a multi-tiered bridge system to support three walkways satisfying the customer requirements outlined in the Crown Center Redevelopment Corporation *Request for Proposal*. In the *Request for Proposal* students are informed that the customer is looking to safely redesign the futuristic, streamlined bridge system previously used in the atrium of their Hyatt Regency Hotel. The management at the Crown Center Redevelopment Corporation still wants to minimize the footprint of the support structure to maximize usable floor space. Therefore, a floating structure look is still

preferred. In addition, students are given minimal construction requirements including the atrium dimensions (length, width, and height), minimum and maximum widths for the walkways, and standard building materials. The students are also informed through the proposal that both aesthetics and functionality will be considered in the final selection process.

After the students receive the *Request for Proposal* and have been debriefed, it is expected that they will meet with the customer (the course instructor) to discuss the customer's desired aesthetics for the design. It is also expected that students will talk with the customer regarding additional design details as well, such as building materials, layout, etc. It is at this point in the case study where students begin to realize the importance of understanding customer needs and communication.

During the second class period the students are required to present their technical engineering solutions to the management of the Crown Center Redevelopment Corporation and submit a final report. In both the presentation and report, students must clearly demonstrate that they have a firm understanding of equilibrium of a rigid body, a fundamental concept taught in the statics course. Students must also demonstrate an understanding of how design is integrated with, and influenced by, the customer needs.

Assessment
In order to assess the impact of the new learning modules, pre- and post-activity surveys were developed and administered. The surveys were approved by the Institutional Review Board (IRB) at Western New England University prior to their use. To maintain confidentiality, students were randomly assigned a 6-digit code that was used to pair responses on the pre- and post-module surveys. The surveys consisted of 5-choice Likert-scale questions that prompted students to rate their current level of knowledge/ability regarding a variety of target EML skills for the respective activities. The post-module surveys also contained free response questions that allowed students to comment on their development during the module as well as things they liked or could be improved. The Likert-scale questions were analyzed using a one-tailed, paired t-test with a significance level of 0.05.

The student population for the present course offerings included 25 students in one section of Statics (ME 202) and 82 students spread across three sections of Probability & Statistics (IE 212). For Statics, 19 students completed both the pre- and post-module surveys (N=19) while 51 completed the pre- and post-module surveys for Probability & Statistics (N=51).

Results
The results from the analysis of Likert-scale questions on the pre- and post-module surveys are shown in Tables 1 and 2. For IE 212, statistically significant changes in student response were recorded for 4 out of 10 EML skills-based questions, including the importance of investigating

the market, identifying an opportunity, identifying supply chains and distribution opportunities, and validating market interest. For ME 202, 7 out of 10 questions showed statistically significant changes in student responses, including the importance of clearly communicating designs, evaluating technical feasibility, evaluating customer needs, developing partnerships and building a team, clearly communicating (within a team and with the customer), time management, and engineering ethics.

Table 1 – Results from surveys in IE 212 (N=51)

Question	Pre-module survey	Post-module survey	P-value	Significance
Importance of investigating the market	2.4 ± 1.1	2.7 ± 1.0	0.02	Yes
Identify an opportunity	2.0 ± 1.0	2.4 ± 1.0	0.01	Yes
Analyze solutions	2.4 ± 1.1	2.5 ± 1.0	0.12	No
Identify supply chains and distribution opportunities	1.9 ± 0.9	2.3 ± 0.9	0.004	Yes
Evaluate technical feasibility	2.1 ± 1.1	2.3 ± 1.0	0.07	No
Evaluate customer needs	2.4 ± 1.1	2.5 ± 1.1	0.22	No
Validate market interest	1.7 ± 1.0	2.1 ± 1.0	0.003	Yes
Clearly communicate	2.9 ± 0.9	2.9 ± 1.0	0.24	No
Time management	2.9 ± 0.9	2.9 ± 1.0	0.43	No
Engineering ethics	3.2 ± 0.8	3.1 ± 1.0	0.09	No

Table 2 – Results from surveys in ME 202 (N=19)

Question	Pre-module survey	Post-module survey	P-value	Significance
Importance of clearly communicating designs	3.1 ± 0.7	3.6 ± 0.6	0.01	Yes
How to identify an opportunity	2.8 ± 0.9	2.9 ± 0.8	0.42	No
Integrate information	2.5 ± 1.1	2.9 ± 0.9	0.09	No
Learn and persist through failures	2.9 ± 0.9	3.1 ± 0.7	0.23	No
Evaluate technical feasibility	2.3 ± 0.9	3.0 ± 0.7	0.003	Yes
Evaluate customer needs	2.7 ± 0.9	3.2 ± 0.6	0.04	Yes
Develop partnerships and build a team	2.9 ± 0.9	3.6 ± 0.6	0.003	Yes
Clearly communicate, including within a group and with the customer	3.0 ± 0.9	3.4 ± 0.7	0.04	Yes
Time management	3.0 ± 0.9	3.5 ± 0.6	0.02	Yes
Engineering ethics	2.8 ± 0.8	3.5 ± 0.7	0.01	Yes

The results from the qualitative free-response questions on the post-module surveys, including the question prompts and relevant representative student responses, are shown below.

IE 212
Please comment on your overall development during this module (e.g., what you have learned, skills you have developed, etc.):

- I find it interesting how we can find certain values and compare them to others in order to make practical decisions and assumptions
- Applying techniques learned in class to a situation in the real world
- I have learned how to analyze and calculate different probabilities and evaluate different problems to find data that tells useful information
- I learned how to study population percentages in order to learn the best and most profitable place to go for work
- I learned that things may be challenging, but everything is able to be completed
- I learned how to identify what a problem is asking for, and how to take the right steps to solve it
- I have learned the intricacies of statistics and the importance of comparing and analyzing information in order to make better decisions
- We have learned all about statistics – how to calculate meaningful statistics from raw data
- I learned how statistics can take what looks to be equal data and distinguish a better choice
- How to analyze data and how to extrapolate from it
- To learn basic probability and statistics about a business market
- I learned that I prefer the engineering side, not the marketing side
- Learned a lot about the application of probability and statistics to an engineering field
- I have learned how statistics can be applied to the real world
- I have developed an understanding of how to analyze data and come up with a solution to meet customer needs
- I learned how to calculate probability in a number of ways that apply to a variety of situations

Please comment on the things you liked about this module, if any, and why you liked them:
- The way we used a real census to figure out the population growth in different regions
- It was simple and easy to understand
- I liked the wide range of information we learned and how they relate to the real world
- It was thought provoking
- Learning the different method of evaluating information to predict what will happen next
- If related to the real world it was more than just some numbers
- I like this topic, but it was brief
- Using real world examples
- It was well organized

Please comment on portions of the module, if any, that could be improved or changed:
- I feel you should include another country to see if it would better to travel overseas
- Make the assignments clearer for instance state what kind of hypothesis test to use
- Go further in depth
- Some questions/directions were not always clear about what was desired/what we were supposed to do

<u>ME 202</u>

Please comment on your overall development during this module (e.g., what you have learned, skills you have developed, etc.)

- Taking broad information/backgrounds for a project and narrowing down to make it my own
- Increased ability to think outside the box
- Teamwork
- Persistently looking for answers
- I've learned that the design process … may require more knowledge than what you are presented with
- Communication is important
- I learned what an engineers' job is like; doing research, asking questions, finding what methods work
- The overall project allowed me to view designs differently by taking my group members ideas and coming together to create an efficient design. Also, I learned how to be flexible when it comes to constraints
- It was an interesting project
- Teamwork, Communication
- Learned the importance of brainstorming; modifying a design is much easier than designing a perfect one from scratch
- I learned that there is much more details and numbers which you need to know and include when doing real world calculations

Please comment on the things you liked about this module, if any, and why you liked them:

- I liked how it was flexible and you could create anything you want
- Openness to creativity
- I like how we have to fix a past failure and essentially make it better
- That it was based off of real events
- Good experience in mock designs
- Working with a team
- Being able to work as a team and get different ideas/opinions

Please comment on portions of the module, if any, that could be improved or changed:

- More time to complete the project. More information on what was expected/desired
- Add slightly more guidelines parallel to our current course
- More knowledge, more time, more points to be earned
- Give more instructions and information about the project
- More specific measurements and instructions
- Should be worth more than a homework grade
- Get groups together earlier
- More time
- Could give options of scenarios; different bridge options

Discussion
The pilot studies for new entrepreneurially minded learning modules in 2nd-year core engineering courses at Western New England University were completed in Spring 2015. Since the results were promising, the modules will be implemented in more sections of the respective courses in academic year 2015-2016. Minor changes to the modules are planned to further address target EML skills in the respective courses.

IE 212
Small changes are planned for the next implementation of this assignment. The module will be pitched to the students in a similar fashion; the students' goal is to convince the CEO of their company to locate a new facility in a particular region. The assignment will be divided into three parts: (1) the students must determine what data they think would be important for this decision, (2) what analyses should be performed on this data, and (3) communicating their decision to the CEO (course instructor). The intent of this change is that it will allow students more freedom to express curiosity as they explore the data space related to the problem.

ME 202
Assessment of the case study shows that focusing on a real-world situation related to statics is engaging to students. Therefore, the topic of the case study will remain unchanged. Implementation, however, can be improved upon. The points listed below will be addressed for future implementation of this module.

The module should be listed in the syllabus as a project. The instructor should also briefly mention that there will be a project at the end of the course. This will notify students early on that they will be expected to complete a design project and should plan accordingly. Along with the module being listed in the syllabus as a project, the weight of what the module is worth towards the total grade should also be listed. The instructor of each section of ME 202 should have equivalent weighting for the module. This will eliminate any "surprises" to students, and differences in grading between sections.

Three key skills that should have resulted from this module (how to identify an opportunity, integrating information, and learn/persist through failures) need to be made clearer to students. These skills should not only be discussed during the module, but also throughout the entire course. To accomplish this, the instructor could introduce the students to EML at the beginning of the semester. Then, during the semester the instructor can relate course and real-world topics back to EML skills.

To remedy the concern that the students felt rushed, the module duration will be extended to two weeks instead of one. Students will also now be provided information at intervals instead of all at the beginning. This will aid students with time management and staying on task. Hopefully

this will eliminate the concern that not enough instructions were given. A significant point of the project was that students were not given all of the necessary information to complete the module. This was done to force students to ask questions, and learn the value of identifying the customer and their needs. Based on the assessment results, this skill was lost on several students. The instructor will need to be conscientious of students becoming frustrated and steer them in the direction of asking questions to gain information.

Acknowledgments

References

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