



Implementing Entrepreneurial-minded Learning (EML) in a Manufacturing Processes Course

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Abstract

At Ohio Northern University, ME-3421 Manufacturing Processes is a technical elective course for juniors in the Mechanical Engineering discipline. Project-based learning techniques (PBL) have been known to underscore skill-based learning outcomes. For this course, PBL was enriched by including Entrepreneurial Minded Learning (EML) activities. EML activities are designed to inspire students' curiosity about the world around them, teaches them to integrate information from many sources to gain insight, and encourages them to creating value by identifying opportunities and working in partnerships with fellow students. It also teaches them to explore a contrarian view of accepted solutions. In the Manufacturing Processes class, two EML modules were developed and deployed in stages. These were (i) a manufacturing process selection activity and (ii) an activity related to environmental and economic impact of manufacturing processes. Both activities included a stakeholder or a customer as well as unexpected design alternatives. In addition, unlike conventional PBL, the project information was kept ambiguous by design, and the customer's requirements were not all clearly spelled out at the project start, and even changed as the project progressed. As an example, during the implementation of manufacturing process selection activity, students interacted with the customer and selected the best manufacturing process for a product based on quantity produced and properties (strength, finish, tolerances, etc.) needed. Students then presented their work to the customer. A few assessments were implemented including written reports, presentations, peer evaluation on teamwork, and a survey. By implementing entrepreneurial minded learning experiences in coursework, students will not only learn the technical theory, but they will be trained to identify problems and solve them in innovative ways.

Introduction

For this work, project-based learning activities (PBL) were modified to include entrepreneurial components. Two modules were developed and implemented in Manufacturing Processes class, an elective at Ohio Northern University. There were 7 students in the class. This course introduces different manufacturing techniques such as casting, rolling, forging, extrusion, drawing, sheet metal forming, machining, and welding. Theoretical as well as practical considerations are covered, including quality control and statistical methods.

Subject-based learning (SBL), and Active Collaborative Learning (e.g. PBLs) have been widely used in the engineering curriculum [1]. Project/problem based activities have been implemented to help students learn new concepts faster. In this methodology, a question or problem is used to drive the students' learning activities to produce a product that can be used in real world. PBL is used to prepare students with skills such as leadership, team building, ethical behavior, creativity, critical thinking, and problem solving [2]. PBL has been implemented as part of the curriculum or as a replacement of the traditional classroom.

EMLs are either designed independently or used by modifying existing pedagogy techniques such as SBL or ACL. EMLs can be implemented either as single homework assignment or as a single week or multiple week-long activities [3]. With experience, an instructor can teach an entire course using such active learning techniques. It is important to understand that

entrepreneurship, in this context, is not necessarily about teaching students how to start a new business, but rather to develop the mindset of innovation necessary to recognize opportunities and make the most of them [1,3]. An enterprise does not need to be created at the end of an EML activity. Entrepreneurial Minded Learning is designed to

- Stimulate **curiosity**. Students are encouraged to demonstrate constant curiosity about our changing world, and explore a contrarian view of accepted solutions.
- Make **connections**. Students integrate information from many sources to gain insight, and assess and manage risk.
- **Creating value**. They do this by identifying unexpected opportunities to create extraordinary value, and persisting through and learning from failure. [4-8].

The tenets above are called the three Cs of the entrepreneurial framework. The EML mindset is being promoted by Kern Entrepreneurship Education Network (KEEN) and implemented at 33 partner institutions [9]. Its goal is to encourage entrepreneurial mindset-based pedagogy within the undergraduate engineering curriculum. Fresh engineers with entrepreneurial mindset skills are prepared for today's job market. In addition to above-mentioned skills, complementary skills such as (i) identifying an opportunity, (ii) developing partnerships and building teams, (iii) finding an engineering solution in terms of societal benefits etc. will also be developed. These skills will reinforce the development of an entrepreneurial mindset.

In this work, first two modules will be presented and then the student assessment will be given.

Entrepreneurially Minded (EM) Course Enhancements:

Two EML modules were created by first looking at the course learning objectives and then modifying project-based learning activities by incorporating entrepreneurial mindset skills.

Module 1: Souvenir Supply Contract Bid

First activity was a classic materials/ manufacturing process selection activity for the students. It was introduced in the 7 week of the semester. This 5-week module required students to prepare a bid for a souvenir supply contract with the university. Just like with most project-based learning modules (PBLs), following was the hook statement – “Your university is planning to celebrate its 150 years of existence in few years. They are planning to sell souvenirs to market the brand and cover the cost of celebrations. Your startup company is bidding for the supply contract.” Student groups were required to select materials and manufacturing process for those articles. In addition, they were to compare the selected manufacturing process with other manufacturing process. Student teams were required to meet with the customer to find out type and number of souvenirs required. The customer in this case was instructor. Deliverables included written reports and a class presentation. The written report would be in the form of a bid document. Students were asked to prepare bid documents as if they were to be used by the university marketing and media department in evaluating potential future giveaway items.

The module was designed with following course learning objectives in mind.

- Identify and summarize the types of the materials used in the manufacturing of a product.
- Apply mechanics of materials and engineering materials science to qualify or quantify the properties of different manufactured products.

- Select the best manufacturing process for a product based on quantity produced and properties (strength, finish, tolerances, etc.) needed.
- Understand the economic, environmental, and societal impact of manufacturing.

For this activity, students formed themselves into teams of 2-3 students. Part of the lecture time was devoted in the beginning to explain students about the module, rubrics, assessments and deliverables. A feedback on student progress was given in week 3 during in class lecture time. Module activities were performed out of class majority of the time. The project stages were as follows: (i) Week 1-2- Types of Souvenirs-Manufacturing process decided and e-mailed. (ii) Week 3-4- the economic and environmental, impact of manufacturing –paper submission. (iii) Week 5- Report and Presentation. Guidelines about how to write a bid were also given [9]. These are given in Appendix 1.

To jump start student discussion, ice-breaking questions/suggestions were given to teams. These were:

- What type of and how many souvenirs will be required?
- Four different materials have to be used in the manufacturing.
- What is the expected cost of each souvenir?
- Is it going to be locally produced or sourced from outside (different state/country etc.)?
- What is the current state of the art for bulk manufacturing of each type of souvenir?
- The souvenirs should be lightweight and with no sharp corners.
- The materials should be non-toxic, water proof, self-supporting, and souvenirs should accurately represent beliefs of university.
- The manufacturing process selected for the souvenirs should waste minimal material and require least number of process steps.
- Two souvenirs should be new designs.
- The selected souvenirs should be able to bulk manufactured.
- One piece can be manufactured using 3-D printing.
- Your “how its manufactured” explanation will not be graded on accuracy, but rather on your thought process and thoroughness.

Module 2: Sustainable Cafeteria Design

This module was staged in two class periods spread over two weeks. It included a summary report with references and a gallery walk. Students were divided into groups of two. In the first class of the first week of the module, students were introduced to the “triple bottom line” concept and were told to summarize three articles related to triple bottom line in a 2-3-page report. The triple bottom line refers to a one method of articulating a sustainable business model: to focus not only on “profit,” but equally on “people” and the “planet.”

Necessary resources such as regional Environmental Protection Agency (EPA) website address were provided. More details are given in Appendix 2. At the end of second week, once they submitted the summary report, following situation was presented to them, “An eccentric oil magnate is donating \$2 million to your university to build a state-of-the-art cafeteria. The only caveat is that it has to be built and operated sustainably. The university is looking for ideas for the cafeteria design. Your company is going to participate in this process. Please select 3 products and/or manufacturing processes that are sustainable. You can select an existing

product/process and give suggestions as to how to make it sustainable.” The instructor acted as representative of oil magnate. Students were required to interact with him to bounce off ideas. Posters and supplies were provided. Student groups then produced posters with solutions that have sections related to triple bottom line. They were supposed to include sketches and visual aids. Additionally, each team was given following information to draw a poster.

- The poster should include three sections related to profit, people and planet.
- You must use sketch/visual aid.
- Write only highlights of the selected idea.
- Your instructor will serve as a representative of the oil magnate and may answer any questions on his behalf.

Then gallery walk was conducted with informal assessment. Students visited the posters and using Post-It notes gave comments about the poster. An instruction sheet was given to them to help assess the posters. To help start the thought process during gallery walk following instructions were given:

With your team, take a look at some of the other posters and think about/discuss:

- How the raw materials/processes selected affects the local environment?
- What other manufacturing methods can be suitable for a given product/idea?
- Pro and cons of the poster/ideas.

In the end, the groups collected comments related to their respective posters and responded to them.

Following course learning objectives were emphasized with module 2.

- Identify and summarize the types of the materials used in the manufacturing of a product.
- Select the best manufacturing process for a product based on quantity produced and properties (strength, finish, tolerances, etc.) needed.
- Understand the economic, environmental, and societal impact of manufacturing.

Assessment of the course in regards to KEEN Student outcomes and complementary skills

With a small student population of 7 students, any statistically-meaningful conclusion will be difficult to obtain. However, below are some anecdotal results for assessment of KEEN student outcomes and complementary skills.

1) Souvenir Supply Contract Bid

This module had elements of entrepreneurial mindset such as (i) Curiosity -which encourages students to explore multiple solution paths. In this activity, students compared different manufacturing techniques for a selected souvenir design, (ii) Connections -where students integrate information from many sources to gain insight into how a part is manufactured. To demonstrate it, students researched innovative manufacturing methods and submitted a report of their work. They had to include references in the report, (iii) Creating value -where students identified unexpected opportunities to create extraordinary value for the customer. For example, Students were asked to prepare bid documents as if they were to be used by the university marketing and media department in evaluating potential future giveaway items. Another example would be that control cost and reduce environmental impact of manufactured goods, student must come up with at least one 3-D printed souvenir in their bid/proposal. Continuing with the entrepreneurial theme this module also touched upon engineering thought and action by encouraging students to apply creative thinking to ambiguous problems. As an example, students

were expected to be creative in identifying an interesting application or product. Students were also required to examine societal and individual needs. In the report/bid document, students demonstrated the concern for societal needs by mentioning that they will source raw materials locally and recruit a local labor force.

Other EML attributes such as collaboration – forming and working in teams, as well as understanding the motivations and perspectives of others – was achieved by student teams via interacting with the customer (instructor) in the first week to ask about souvenirs and better understand the needs of the customer. Lastly, communication skills which can manifest as identifying and organizing information in a format suited to the audience were demonstrated by students submitting a report and giving a class presentation.

2) Sustainable Cafeteria Design

The three Cs of entrepreneurial Mindset such as (i) Curiosity (e.g. observes trends about the changing world with a future-focused orientation/perspective) was demonstrated by students by evaluating claims by different organizations regarding triple bottom line, (ii) Connections (e.g. connect content from multiple courses to solve a problem) was shown by students utilizing knowledge from materials science, renewable energy, & mechanics courses to evaluate existing technologies/strategies to find meaningful solutions, (iii) Creating Value (e.g. create solutions that meet customer needs) was determined by students by visually displaying solutions via poster during gallery walk activity.

Other EML attributes such as engineering thought and action e.g. apply creative thinking to ambiguous problems was addressed by students via demonstrating alternative ideas related to integration of sustainability principles in cafeteria design. Aspects such as examine societal and individual needs were demonstrated by students studying and summarizing articles from reputed sources on the triple bottom line.

Continuing with the entrepreneurial theme, skills such as collaboration were demonstrated by students via self-select partners and working together to produce report and poster.

Understanding the motivations and perspectives of others was shown by students researching articles and summarizing them in a report or during gallery walk where they also visited other student's posters and give comments using post it notes. Students were given experience in providing and accepting constructive criticism during the gallery walk exercise.

3) Student feedback

Student survey was taken after both activities. For the souvenir project, students were asked if they would like this project be repeated and they said yes. Students especially liked the gallery walk experience. One student commented, "Provoked thought and practice with idea generation," other said, "Interactive with peer input." Looking at the student feedback and direct evaluations it seems students liked the activities of both modules and presented a detailed report and posters. Their presentations were truly interactive and used copious amount of graphics in the posters. The gallery walk activity provoked thought and practice with idea generation. There is scope of improvements. The instructions given can be clearer. For example, some students said the number of types of souvenirs was large. This resulted in some students giving 8-page report while others gave a 20-page report. For the souvenir module the number of articles should

be capped to 6-8 and different manufacturing processes should be compared. Moreover, students should be asked to visit a vendor to determine a reasonable price structure for the souvenir. The triple bottom line module can be introduced in the early (e.g. second week) part of the semester. The summary report should be collected and then the gallery walk can be done.

Conclusion

This paper describes implementation of two EML modules in a manufacturing processes course. In first activity, students were asked to prepare bid documents as if they were to be used by the University Marketing and Media department in evaluating potential future souvenir items. The students also did an oral presentation in class and a write-up. In a second activity, students wrote a summary report and using gallery walk produced solutions for the customer. Based on the students' feedback on the assessment, the author believe the EMLs were a success. This meaningful and enjoyable experience would help the students succeed in their future courses and career development. It should be mentioned that although this EMLs were designed for manufacturing processes course, the project could also be used for other classes with similar learning objectives, e.g. Material Science courses.

References:

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Appendix 1 Souvenir Module Description

Materials and manufacturing process selection for Souvenirs for universities 150 year celebrations

-The _____ Souvenir Company

Learning Objectives

Upon completion of this module, the students will be able to:

1. Identify and summarize the types of the materials used in the manufacturing of a product.
 2. Apply mechanics of materials and engineering materials science to qualify or quantify the properties of different manufactured products.
 3. Select the best manufacturing process for a product based on quantity produced and properties (strength, finish, tolerances, etc.) needed.
 4. Understand the economic, environmental, and societal impact of manufacturing.
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1. Teaming - team size -2 students and self-select.
 2. Deliverables and student assessment
 1. deliverables include written reports, presentation.
 2. student assessment includes report, presentation.
 3. Deployment and staging schedule
 1. Duration: module-3-4 weeks,
 1. in-class- Half lecture in beginning and feedback on week 3 Half lecture
 2. out-of-class-majority of the time.
 2. Stages:
 3. Week 1-2- Types of Souvenirs-Manufacturing process decided and e-mailed.
 4. Week 3-4- the economic and environmental, impact of manufacturing –paper

Instructions:

You must work in a team of two of your choosing. Submit one report for your team.

Suggestions for moving forward.

Interact with customer. Select the number of articles aka souvenir's. Then select a material and manufacturing process for those articles. Compare the manufacturing method selected with other manufacturing method.

Format:

6-8-page report.

Report will have abstract, Introduction, Figure, result/findings, conclusion

Hook Statement- The Souvenir Company

Your university is planning to celebrate its 150 years of existence in a few years. They have decided to sell souvenirs to market the university brand, connect with alumni, generate sufficient funds to support students e.g. scholarships and cover the cost of celebrations. Your background

of materials science and manufacturing course work will help your startup company in bidding for the supply contract.

Preliminary investigation question suggestions:

- What type of and how many souvenirs will be required.
- Four different materials have to be used in the manufacturing.
- What is the expected cost of each souvenir?
- Is it going to be locally produced or sourced from outside (different state/country etc.)?
- What is the current state of the art for bulk manufacturing of each type of souvenir?

Some considerations:

- The souvenirs should be lightweight and with no sharp corners.
- The materials should be non-toxic, water proof, self-supporting, and souvenirs should accurately represent beliefs of university.
- The manufacturing process selected for the souvenirs should waste minimal material and require least number of process steps.
- Two souvenirs should be new designs.
- The selected souvenirs should be able to bulk manufactured.
- One piece can be manufactured using 3-D printing.

Your “how manufactured” analysis will not be graded on accuracy, but rather on your thought process and thoroughness.

Guidelines for writing a bid

Although the reputation of your business is important, your bid must be detailed, organized and realistic to prevail over other those of the contractors.

Calculate the costs for all supplies and expenses. Once you determine what the job entails, add up all the supplies needed, other expenses, labor costs and the amount of time you expect to spend on the job. Supplies include any materials needed to do the job. Expenses are any travel, lodging or meal costs, as well as subcontractor or equipment rental fees.

The university requires federal minimum pay for labor or the use of at least 1 minority contractors for a portion of the work.

Check to make sure you are making a profit from the job and that all expenses, including any overhead costs, are calculated into the bid.

- Overhead refers to business expenses that are not related to direct materials or labor. Overhead expenses must be paid no matter what the volume of your business is. These can include insurance, rent and utilities. Overhead must be built into any bid or you risk not making a profit on the job.^[1]
- For the souvenirs bid you might need to include a portion of the salary of an administrative assistant, rent or mortgage for office space, worker's compensation insurance and cost of utilities. Usually, these expenses are built into the retail price of the

souvenir rather than itemized separately. Just don't forget to include them when you are preparing your bid.

- In addition, you should always add a contingency budget equal to 5%-10% of the total estimated cost.

All cost information should be in line-item form so that your client knows exactly what the bid includes. Specify any limitations, exclusions or stipulations for the bid, like limiting hours of work, specific safety requirements, etc. Your contact information, company name and payment requirements should appear prominently on the bid proposal.

Create tables that show exactly how you arrived at each price -- costs for labor and supplies, for example, plus a markup for your profit. Double check to make sure your estimates for the cost of supplies and labor are realistic. Aim to offer the best value, not necessarily the lowest price. Give yourself some leeway to absorb cost overruns and unexpected delays, especially when dealing with subcontractors.

Appendix 2-The Triple Bottom Line

Manufacturing industries often struggle to balance profit with other social responsibilities. For instance, hazardous byproducts are often difficult or expensive to avoid, and preserving a safe work environment around powerful and fast-moving machinery frequently reduces efficiencies of space, maintenance, and operation. An engineer is typically under pressure to focus on the “bottom line,” maximizing profit by achieving optimal output with minimal expense.

In this exercise, you will look at several articles discussing how various companies are focused beyond the traditional bottom line (profit), emphasizing instead a broader definition of success sometimes called the “Triple Bottom Line” – people, planet, and profit. This is a common measure of corporate social responsibility.

Tasks:

- Find three articles highlighting this type of effort or achievement by different companies. These cannot be self-reported, where companies are blowing their own horn; they must appear in the independent press. One example of the articles can be:
<http://www.limaohio.com/archive/22910/news-business-news-1266278-ohio-epa-recognizes-crowns-environmental-efforts-in-new-knoxville>

Additional references:

<http://epa.ohio.gov/News/OnlineNewsRoom/NewsReleases/tabid/6596/articleid/1216/ohio-epa-issues-2017-encouraging-environmental-excellence-awards.aspx>

- Write a 3-4-page report including the following sections:
 - Summary of each article *in your own words*.
 - Reflection
 - Your impressions, potential impact of this news / development.
 - Potential application of the efforts highlighted in your articles to other industries or to society in general.
 - Consider the following scenario: You are a major stockholder in a company whose stock dropped after posting earnings of only \$1.20 per share. In her quarterly report, the CEO acknowledged that earnings would have been \$2.50 per share had they not voluntarily adopted more environmentally-friendly processes and policies. Your stock value plummeted \$250k. What is your reaction? What ethical issues are at stake here?
 - References according to SAE format on page 2.

This will count as a double homework grade (20 pts). Your paper will, in part, be evaluated based on the attached rubric.

Grading:	15	Summary / Reflection / References
	<u>5</u>	Format / Grammar / Style
	20	

For a Gallery walk related to the triple bottom line activity, following instructions were given to students.

With your team, take a look at some of the other posters and think about/discuss:

- How the raw materials/processes selected affects the local environment?
- What other manufacturing methods can be suitable for a given product/idea?
- Pro and cons of the poster/ideas.

Following information was given to jump start the discussion among students during the poster preparation as well as gallery walk. They were asked to include all or some of the following points in their poster.

For Cafeteria

- 1) Utensils-type and manufacturing method
- 2) Solar thermal/ geothermal water heating, - hot water for cleaning/cooking/building heating.
- 3) Solar PV panels
- 4) Recycled pipes for support columns for the building
- 5) Beetle destroyed wood recycled as furniture and décor.
- 6) Low flush toilet
- 7) Glass façade to create greenhouse effect.
- 8) LED lamps.
- 9) Recycled construction material.

For people

- 1) Hiring practice e.g. Hire physically challenged employees.
- 2) War veterans.
- 3) Policy that accepts and implements employee suggestions.

Economics

- 1) Lower cost
- 2) Increase revenue
- 3) Brand
- 4) Recruiting

Long term benefits due changing social mindsets. People willing to pay more for sustainably produced products.