

AC 2010-1780: INCORPORATING ENTREPRENEURSHIP INTO A HANDS-ON FACILITY PLANNING COURSE

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Incorporating Entrepreneurship into a Hands-on Facility Planning Course

Abstract

The past two decades have seen entrepreneurship emerge as a mainstream business discipline in the United States. Universities are now being expected to inspire entrepreneurship in order to prepare students to succeed in a globally competitive business setting. This paper discusses how the concepts and practices of entrepreneurship are incorporated into a college level facility planning course. Such a course carries three-credit hours, and is comprised of a weekly two-hour lecture and a two-hour lab. Important entrepreneurial concepts are first introduced to students, such as identifying opportunities, creating a business plan, and analyzing the market to determine the target customers. Students will then develop the product and determine the customer demand based upon the market analysis. This paper discusses those tasks as part of students' projects, ranging from determining the number of workers and machines required by the facility, to the total cost required to start the businesses. Outcome of the course was evaluated by pre and post evaluation instruments conducted by an external professional evaluator. It is demonstrated that the course objectives and ABET requirements were met by student projects, reflections and the evaluation instrument.

1. Introduction

The recent globalization of business and engineering practices present both challenges and opportunities to the professionals of engineering education¹. The past two decades have seen entrepreneurship emerge as a mainstream business discipline in the United States². Universities are now expected to inspire entrepreneurship in order to prepare students to succeed in the globally competitive business setting³. Entrepreneurship, as a core business skill, has become an increasingly popular course in the curriculum of business colleges. Its popularity results from not only college students who are interested in it, but also from the businesses who hire those college graduates⁴.

A number of universities are currently teaching entrepreneurship courses to their engineering students. Among them are MIT, Stanford University, and Brown University. MIT offers their student a wide variety of classes in launching, managing, and growing technology-based businesses. They use many different teaching methods in these classes that include case studies, internships, guest lectures, external reviews of student assignments by venture capitalists, and student projects. These courses also help students focus on learning how to effectively work as a team and on presentation skills. Another thing which MIT did to promote entrepreneurship is the holding of an annual contest, the MIT \$50K Entrepreneurship Competition, where the winning team is awarded a \$50K grant which is intended to assist them in starting their business. This contest is open to all undergraduate and graduate students¹.

European nations are also beginning to introduce entrepreneurship courses into engineering education. One example of this is the Instituto Politécnico de Viseu located in Viseu Portugal. Instituto Politécnico de Viseu introduced an Operations Management course that combined designing, organizing, and operations strategy with the entrepreneur mindset. In the first four weeks of the class the students are formed into teams and focus primarily on learning the main concepts of designing, organizing, operations strategy, and entrepreneurship by performing case studies that are presented in class. By the end of the four week period each team of students will have an idea for a service or product which they intend to work with. These ideas are worked on throughout the duration of the semester. The final project is a 10 minute PowerPoint presentation where each group discusses their ideas and is asked any questions that the audience may have regarding their idea or work³.

Having interviewed with many local industrial leaders, the authors concluded that many CEOs of larger firms are seeking new engineers that have entrepreneurship skills, because, in their minds, entrepreneurship skills enable managers to take a project from initiative to success. Entrepreneurship skills is not simply opening a new venture or business; rather it is the capability of taking something new and molding the idea in order to accomplish an important mission. Entrepreneurship skills can be applied to a plethora of industries and is a valuable skill-set that will enhance the prowess of managers and employees in the workforce. Incorporating entrepreneurship into engineering curriculum thus better prepares students to be competitive in the economy. There is a real need for entrepreneurial courses geared towards engineering students within their discipline in order to express their creativity, practice opportunity recognition, and utilize experiential learning, allowing them to better apply entrepreneurship concepts and abilities to their future careers.

To develop entrepreneurship skills within most engineering curriculums, there are two options. One is for each discipline to create a new course designed for teaching entrepreneurship and the above mentioned knowledge. However, this option is not easily feasible due to the fact that most of the engineering curriculum are heavily loaded in order to meet the criteria from a national accreditation agency such as ABET. The only plausible option is to renovate one of the existing teaching assignments into a course that not only meets the curriculum requirements of the degree program, but also allows students to gain knowledge of creativity, opportunity recognition, and hands-on learning in entrepreneurship.

With such a passionate and devoted faculty, the development and delivery of such a renovated course would not only remain within the core competency requirements of the degree but would also include hands-on entrepreneurship experience by further developing students' entrepreneurship skills and aspirations.

The following paper will first discuss a hands-on entrepreneurship course curriculum model incorporating facility planning, followed by the explanation of key concepts in entrepreneurship. It will then discuss the actions taken in a class project and the results. The paper will then conclude with an analysis of student comprehension of entrepreneurship as well as a discussion of the student benefits.

2. The Proposed Curriculum

The proposed Facility Layout/Entrepreneurship course carries a three-credit hour load and is comprised of a weekly two-hour lecture as well as a two-hour lab. The final result of this course is to develop an idea for a product or service and to build a proposal to try to sell the idea. The students will develop a PowerPoint presentation throughout the project and will present it to a peer for an evaluation. The peer will play the role of a banker and will determine if the investment is well thought out and if they believe that it will succeed. When the first student is complete they switch places and the presenter becomes the evaluator and evaluator the presenter. This is beneficial for the student developing the presentation as well as the student evaluating it because they have the opportunity to see ideas from different perspectives.

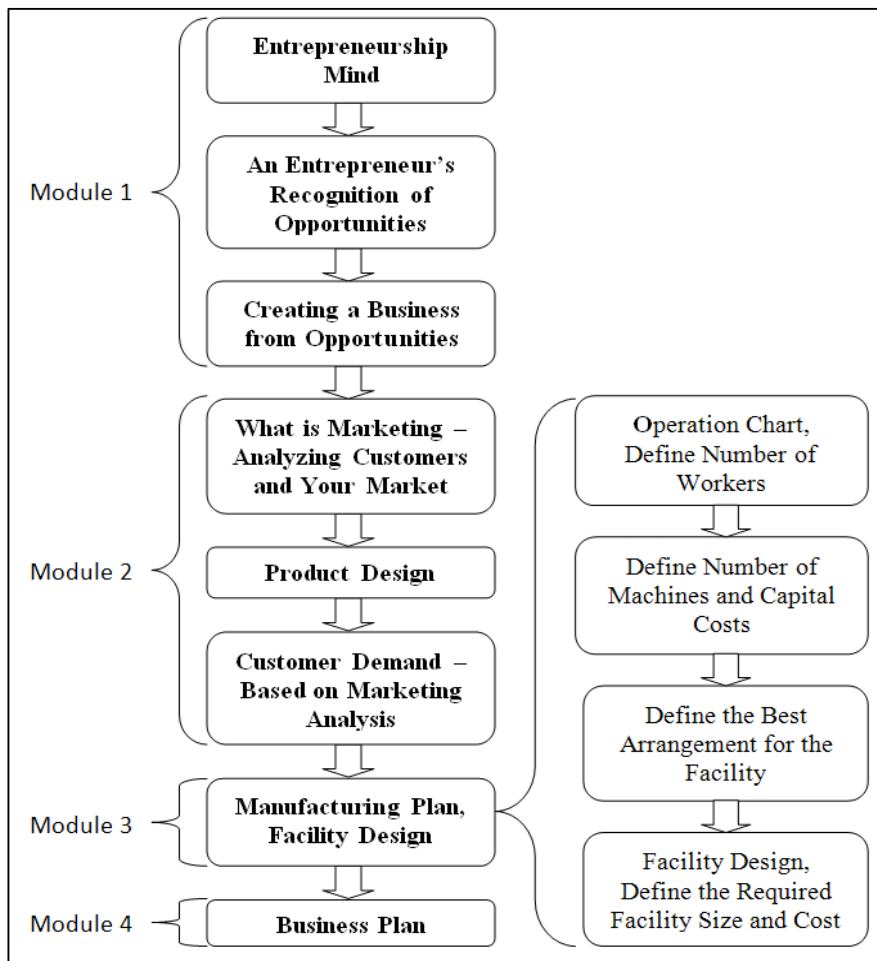


Figure 1. Flowchart of the proposed course

Figure 1 shows the flow of this proposed course. This course consists of four modules, which are summarized below.

Module 1: Entrepreneurial Opportunity

This module focuses on the following subjects:

- Overview of entrepreneurship and preparation
- The entrepreneurial mind: crafting a personal entrepreneurial strategy
- Recognizing and creating opportunity
- Developing a business model for the new venture.

Module 2. Feasibility Analysis

Throughout this module, the students will learn the process of feasibility studies in order to test their business concepts.

Key areas of focus are:

- Analyzing the industry and market for the potential of a new venture.
- Understanding the product/service potential risks and benefits.

Module 3. Manufacturing Planning and Capital Options

In this module, students will learn all the necessary techniques of facility planning via the new venture idea. The main purpose is for students to use the techniques in order to minimize the costs associated with the creation of a new facility for the new venture. Based on the new facility design and necessary service or production needs, the students may realize the cost and decide to further define the potential sale price of the new venture. From these exercises, the potential profit for the product could be identified and assist in the development of a balance sheet to be included in the upcoming business plan.

The key areas of focus are:

Stage 1 – define necessary capital for equipments based upon product demand determined from marketing information

Stage 2 – utilize techniques to optimize the facility layout and finalize the facility design

- Use process chart techniques to optimize the layout of all machines and equipment.
- Use relationship charts to define locations of service units within the factory, such as restrooms, break rooms, etc.
- Define the required number of managers as well as defining the office building with the potential of expansion in mind.

Stage 3 –Include necessary auxiliary service spaces, office areas, and material handling equipment

Stage 4 – Propose a financial plan for a new start-up

Module 4. The Business Plan

In this module each student will finish a business plan, which will be in presentation format.

- Complete a business plan presentation in PowerPoint format.
- Present the presentation to a peer that is acting as a loan officer.

3. Modules of the Curriculum

In this section, the key components comprising of the course (in Figure 1) are described in further detail.

3.1 Module 1: Entrepreneurial Opportunity

Entrepreneur Mind

A personal assessment is conducted to determine the level of entrepreneurship mindset of each of our students. The personal assessment consists of a list of predetermined questions that ask about the career plan of students after graduation and about their desire to develop and pursue an idea or business of their own. Based on the results, very few students showed little or no desire to be an entrepreneur. A large majority of the students showed a moderate interest in being an entrepreneur, however, their degree of interest showed that they were open to the entrepreneurship but they were not likely to devote a lot of time to pursue it. They were much more likely to go out and find a job with an existing company. There were some students who had a high interest in entrepreneurship and were ready and willing to put in the time and effort to pursue a career in entrepreneurship, but the overall percentage of these students was rather low.

An Entrepreneur's Recognition of Opportunities

Opportunities for entrepreneurship are abundant in the world where we live in. One of the most difficult things to do is to recognize these potential opportunities. In order to help our students to see all of the potential opportunities for entrepreneurship, we had them take a survey. The survey asked about problems or obstacles that are encountered when going about their daily lives. The survey showed the students all of the potential problematic situations that exist which could be capitalized on by developing a new product or service.

Creating a Business from Opportunities

Once the survey had been completed and the potential opportunities that exist had been recognized by each student, the class came together as a group. The areas of potential opportunity that each student identified were shared with the class. Each of the ideas were compared to one another to identify the top ideas with the best potential. One of the next steps performed by students is to design the company. Students started from developing the name of the company for the service or product that it provided. This is beneficial because it showed the students that there are many possibilities for entrepreneurship and it also showed them other people's ideas to help them think more broadly.

3.2 Module 2. Feasibility Analysis

What is Marketing – Analyzing Customers and Your Market

Once the company was developed, students began to work on a flier to advertise their company. The flier was to be directed towards potential customers. It was to show the name of the company, the product or service, contact info, and any other information that might be relevant. Having the students develop the company name and flier gave them an idea of the

steps that must be taken to start up a company. Along with the development of the fliers, the students developed a simple survey that was given to no fewer than 5 people per student in the team. Having the students develop, hand out, and view the results of the survey helped them see how their idea might be seen by the public. It also helped them see how they could change their product or service to better suit the customer's needs.

Product Design

With the development of the identified opportunities, the next step is to identify a product or service that will meet the need. Once the product or service that will solve the identified obstacle is developed, the following step is to develop a bill of materials. The bill of materials is a list of all the materials with the amounts of them that are contained in the product. This list is used to determine the overall cost of each product.

Customer Demand – Based on Marketing Analysis

Knowing the potential customer demand is extremely important for running a business. It enables the business to find many different factors that would affect a company, such as how many employees and machines are needed to build the necessary amount of the product, how big the facility needs to be to house all of the processes that need to take place, what the capital cost going to be when the company starts up, and most importantly, how much profit the company will be making. In order to calculate the customer demand students must take the yearly demand and calculated demand per shift. Once that was calculated students must figure out the value added time that was put into making the product. Students then took the value added time divided by the demand per shift to determine the takt time. With this data they could then determine the number of employees that were needed to meet daily demand.

3.3 Module 3. Manufacturing Planning and Capital Options

After the classroom lectures which introduced the fundamental tools to begin an entrepreneurial venture were completed the students were given a project to work on. The project that was assigned in this course was to develop a proper facility layout and business plan. To help ensure grading was fair, each student was given the same design of the product that they would be manufacturing, which was a toolbox displayed below in Figure 2. Due to the assignment being an in-class project, the students were also provided with their expected yearly demand and the machines which they would be using to manufacture their product. The goal of this project is to show the students the steps that are required in starting a company.

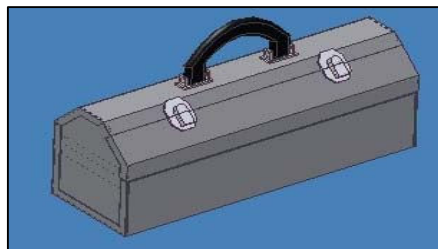


Figure 2. Product that was identified for the project

Operation Chart, Defining the Proper Number of Workers

With the bill of materials defined, the production methods can now be designed. Students have to determine how each piece will be cut, formed, and assembled together. Once these steps have been determined, an assembly chart can be designed. An assembly chart, as shown in Figure 3, is a visual display that shows individual components path that it takes from raw material to a finished good.

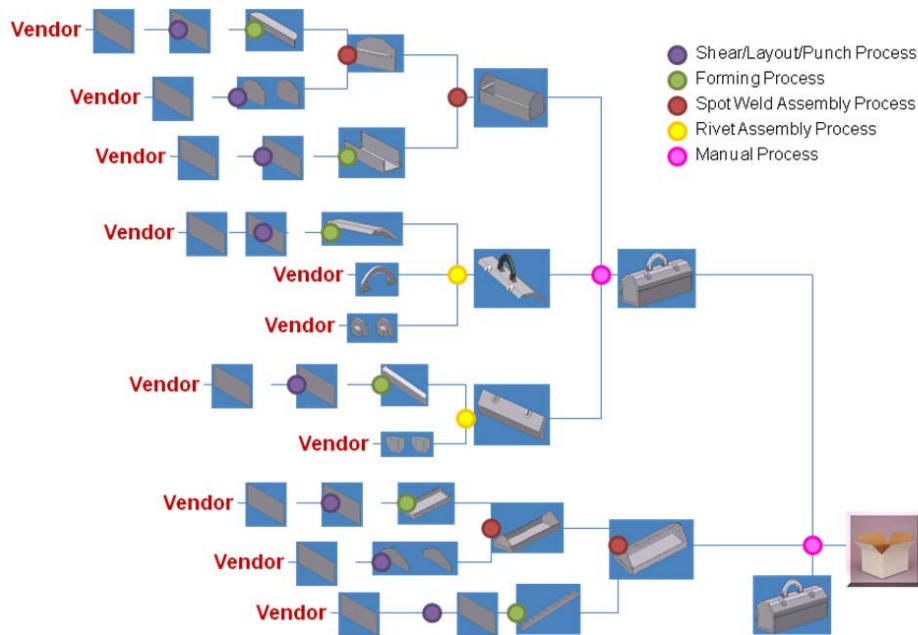


Figure 3. Example of an assembly chart

Once the overall assembly chart has been designed, the individual process charts can be designed. These are very similar to the assembly chart but they are for the sub-assemblies in the product. The main reason for constructing process charts is to be able to more easily see the processes that take place in the sub-assemblies production.

The next step that takes place is the development of an operation chart (Figure 4). An operation chart shows how many pieces can be manufactured at each step in an hour and also how many hours it takes to manufacture 1000 pieces. This information is very useful because it is used in determining the number of workers that are needed to meet customer demand.

Defining the Number of Machines Required and the Associated Capital Cost

Once the rate per hour of each piece has been defined, the number of machines needed can be calculated. To do this, the rate per hour of each of the pieces is input into a chart. From there the standard time can be calculated. In order to find the standard time the effective minutes per hour must be divided by the number of pieces per hour. Once the standard is determined, the total number of machines needed can be found (Figure 5). To do this the standard time is divided by the takt time.

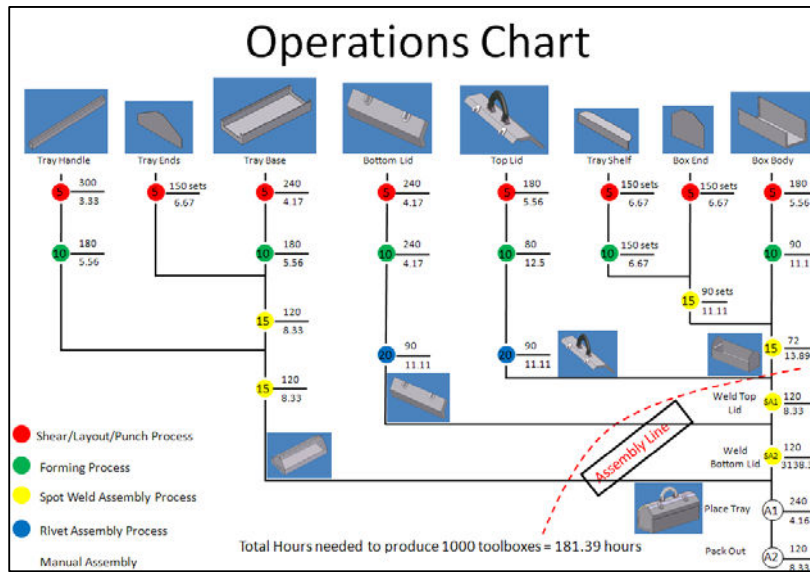


Figure 4. Operations Chart

Based on your stage 1, what is your Takt Time = 0.389														
Based on the standard time and takt time, define # of machines are needed for each related operation.														
Machines/Piece	Part Name	Body	Body ends	Tray Shelves	Bottom Cover assembly	Top Cover w/handle	Tray	Tray Ends	Tray Handle	A1	A2	A4	Total Machines	Adjusted Machines
	pieces required per toolbox	1	2	2	1	1	1	2	1	1	1			
	Trumatic 5000	0.796	0.956	0.956	0.599	0.796	0.599	0.956	0.478	-	-	-	6.136	7
	TrumaBend V50	1.593	-	0.956	0.599	1.794	0.796	-	0.796	-	-	-	6.534	7
	Spot Welder	1.992	1.593	-	-	-	1.195	-	1.195	1.195	1.195	-	8.365	9
	Riveter	-	-	-	1.593	1.593	-	-	-	-	-	-	3.186	4
	Auto Sealer	-	-	-	-	-	-	-	-	-	-	1.195	1.195	2

Figure 5. Calculations for the number of machines needed

The next step is to define the assembly line structure. The standard time is divided by the takt time in order to get the number of required stations. This displays the number of each machine that is needed to meet the defined takt time. Once the number of machines required is found, an assembly line layout can be made. After this is done the last thing to do is to update the number of workers that are needed in the facility to make sure that there is at least one worker per machine.

Once the number of machines has been determined a total machine cost can be calculated. To do this the number of machines is multiplied by the cost of each machine. That number is then multiplied by 10% to factor in the cost of tooling and then that number is added to the

previous result.

Defining the Best Arrangement for the Facility

The next key tool that the students used is the relationship chart. Figure 6 shows one example of the relationship chart defined by students where all of buildings specific areas, (office, shipping, locker room, etc...) were listed and were determined with the relationship between them. Doing this helps to determine which areas need to be located near each other and which areas should not be near each other in the facility.

Once the relationship chart was completed and the number of machines needed was calculated, the students determined the floor space needed for each individual type of machine and the floor space for each processing area along with additional areas such as restrooms and break rooms which is demonstrated in Figure 7. With these areas determined a rough layout can be constructed. The students made a paper layout in which they placed each of the areas in a specific arrangement based on the relationship chart. The main thing that the students learned from this activity is how to properly develop a floor plan for a facility and how a well developed floor plan can cut costs and increase profits.

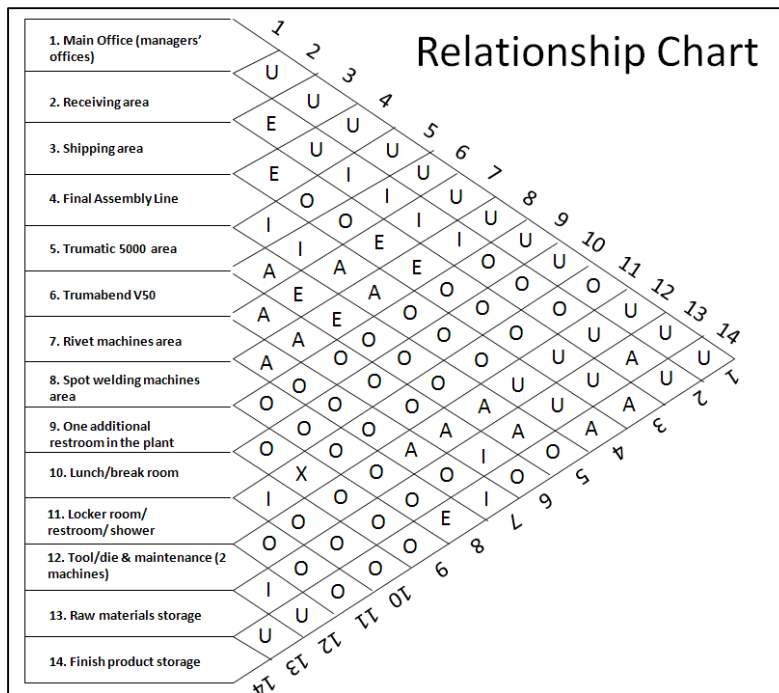


Figure 6. Relationship Chart

Facility Design, Defining the Needed Facility Size and Cost

With the rough layout determined, the next thing to do is to determine the overall size of the facility. When determining the size of the structure, one needs to consider that it needs to be large enough to hold all of the processes and storage along with aisles but it should not be made excessively large in order to keep the cost down. Once the size of the facility was determined the students plotted out the location and orientation of each of the individual

machines and areas. When doing this they had to be sure to incorporate aisles for both material handling as well as machine maintenance. They also had to keep in mind that the machines should be laid out to allow for the best and most efficient flow possible so that their facility could obtain the greatest possible profit. Figure 8 shows one example of the entire proposed facility layout.

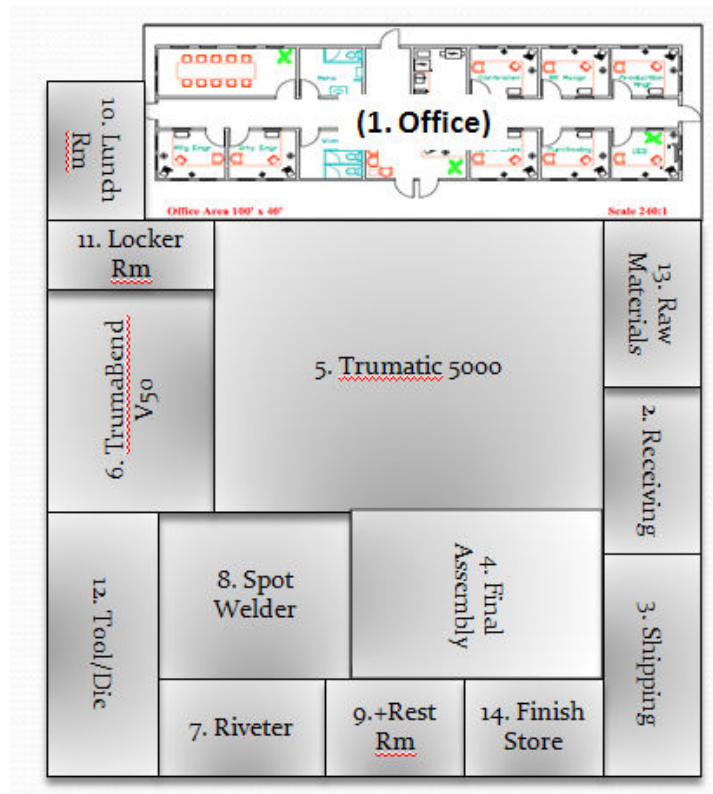


Figure 7. Initial, rough facility layout

Financial Statement for the Business Plan

Once all of the costs that are associated with starting up the business were calculated the students constructed a 12 month cash flow chart (an example is shown in Figure 9). The cash flow chart displays the amount of money that is initially borrowed and what all of the additional monthly expenses are. It also shows the principal that remains on the expected loan, the net profit of the company, and the payback period (in most cases the net income should be positive by the end of the 12 month cash flow chart). This part of the project is extremely important for the students to understand because if they want to start a company or even to just implement a new idea or setup, they would have to be able to show how much money is needed and how fast the idea or change will pay for itself. This information is also needed in their business plan to show how the company they are proposing can be successful.

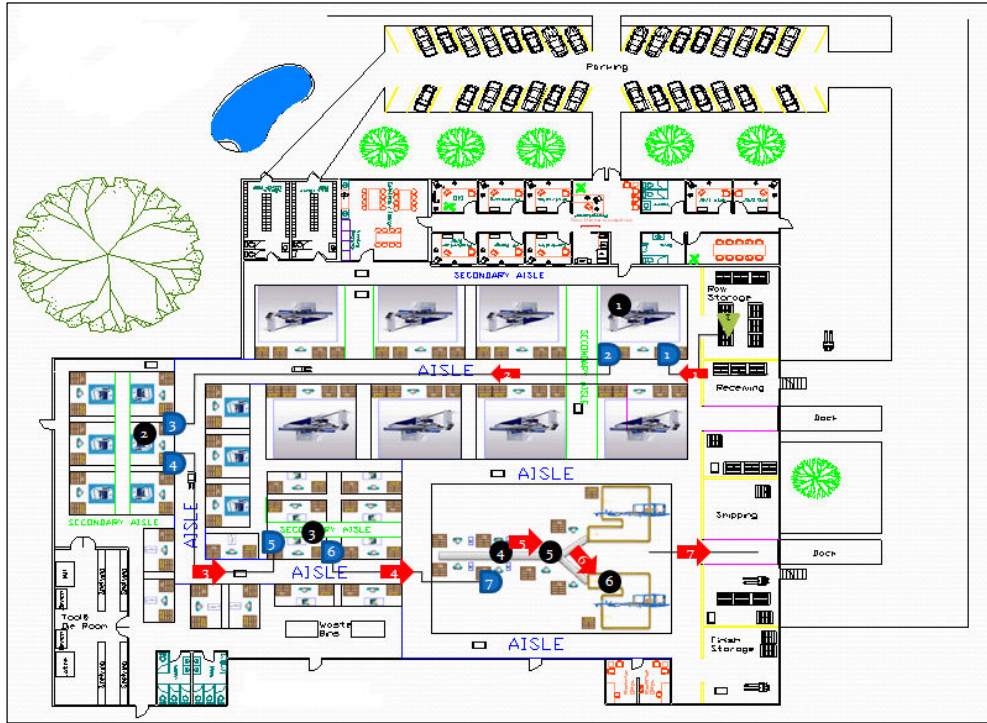


Figure 8. Proposed facility layout

	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09
		Raw Mat/Unit: \$ 10		Loan Principal: \$ 12,498,300		Unit Price:		Interest Rate:
Cash on Hand	\$ -	\$ (1,496,393)	\$ (1,148,145)	\$ (799,898)	\$ (451,650)	\$ (103,403)	\$ 171,392	\$ 363,747
Cash Receipts								
Total Cash Sales		\$ 1,844,640	\$ 1,844,640	\$ 1,844,640	\$ 1,844,640	\$ 1,844,640	\$ 1,844,640	\$ 1,844,640
Total Cash Available	\$ -	\$ 348,248	\$ 696,495	\$ 1,044,743	\$ 1,392,990	\$ 1,741,238	\$ 2,016,032	\$ 2,208,387
Cash Pay Out								
Purchases	\$ 614,880	\$ 614,880	\$ 614,880	\$ 614,880	\$ 614,880	\$ 614,880	\$ 614,880	\$ 614,880
Hourly Wages	\$ 282,000	\$ 282,000	\$ 282,000	\$ 282,000	\$ 282,000	\$ 282,000	\$ 282,000	\$ 282,000
Salary Expenses	\$ 28,750	\$ 28,750	\$ 28,750	\$ 28,750	\$ 28,750	\$ 28,750	\$ 28,750	\$ 28,750
Overhead	\$ 50,000	\$ 50,000	\$ 50,000	\$ 50,000	\$ 50,000	\$ 50,000	\$ 50,000	\$ 50,000
Subtotal	\$ 975,630	\$ 975,630	\$ 975,630	\$ 975,630	\$ 975,630	\$ 975,630	\$ 975,630	\$ 975,630
Principal Left	\$ 12,498,300	\$ 11,977,538	\$ 11,456,775	\$ 10,936,013	\$ 10,415,250	\$ 9,894,488	\$ 9,373,725	\$ 8,852,963
Loan Principal Payment	\$ 520,763	\$ 520,763	\$ 520,763	\$ 520,763	\$ 520,763	\$ 520,763	\$ 520,763	\$ 520,763
Interest	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Total Expense	\$ 1,496,393	\$ 1,496,393	\$ 1,496,393	\$ 1,496,393	\$ 1,496,393	\$ 1,496,393	\$ 1,496,393	\$ 1,496,393
Pre Tax Income	\$ (1,496,393)	\$ (1,148,145)	\$ (799,898)	\$ (451,650)	\$ (103,403)	\$ 244,845	\$ 519,639	\$ 711,995
Tax (30%)						\$ 73,454	\$ 155,892	\$ 213,598
Net Income	\$ (1,496,393)	\$ (1,148,145)	\$ (799,898)	\$ (451,650)	\$ (103,403)	\$ 171,392	\$ 363,747	\$ 498,396

Figure 9. Example of a 12-month cash flow chart

3.4 Module 4. The Business Plan

Once the students had fully developed their idea the final task was to create a business plan. The business plan is a PowerPoint presentation which gives a thorough explanation of the

students' idea. It should contain everything from what the product is, to how they planned on building it, to a 12 month cash flow diagram. Once the business plan was finalized the students presented their ideas to a peer that was acting the role of a loan officer. They must evaluate the presentation as if they were actually a loan officer and determined if they believed that the proposal was well planned and thought out and if the idea would succeed. Once the first student had given their proposal to the loan officer, he or she then became the loan officer and the student that was the loan officer presented his or her business proposal.

4. Students' Course Feedback

This course was first developed and delivered in the fall semester of 2008. Although the objectives of the course had been developed, the authors did not have enough time to fully develop an outcome assessment tool for the course. It is the authors hope to begin with two learning feedback tools to help in developing a full scaled outcome assessment instrument. These two reflection processes are (1) student's self-assessment with nine key skills or knowledge related to the course; and (2) each student submits one-page reflection essay where the student summarizes his or her learning throughout the course.

Assisted by an external professional evaluator, the authors developed a self-assessment instrument which was used for students to self-evaluate himself or herself in nine key skills before and after taking the course. The self-assessment data has been analyzed as shown in Table 1.

Table 1. Results of self-assessment pre and post tests (sample size: 39)

Knowledge/skill	Pre-test μ	Post test μ	t	PROB.> t
Interpersonal Skills	7.14	7.14	0.00	1.000
Management Skills	6.25	6.71	-1.824	0.079
Engineering Knowledge	6.64	7.18	-1.598	0.122
Budget Knowledge	5.93	6.32	-1.323	0.197
Manufacturing Knowledge	7.00	7.71	-3.116	0.004
Organizational Skills	6.71	7.14	-1.563	0.130
Creativity	6.50	6.57	-0.238	0.813
Research Skills	6.15	6.46	-1.162	0.256
Marketing and Sales Knowledge	5.32	5.79	-1.455	0.157
Enthusiasm	6.89	7.43	-2.105	0.045

The mean rating of personal skills by students shows that student self perception of skills in several areas increased significantly. In particular, the areas of manufacturing knowledge and their enthusiasm increased to a meaningful degree (nearly 1 point on the 9-point scale.) When one totals all 10 areas for a pre and post total self evaluation, the difference remains significant at the 95% confidence level.

In addition to the self-assessment data demonstrated, the reflective essay written by each

student also demonstrated that the students enrolled in the course enjoyed the opportunity to gain knowledge and skills in the understanding of entrepreneurial processes. The following are a few quotes from students' reflective essays.

- *“If you would have asked me how to start a business of my own a couple of months ago I would have had pretty much no idea. Now with the knowledge that I have learned from this course, I feel that I could make a good attempt at being an entrepreneur.”* (N.H.)
- *“This project gives us students a way to see everything we did throughout the semester and put it into one facility that should hopefully make money and be efficient.”* (J.R.)
- *I feel I learned a lot about the overall starting up of a company and I feel everyone can use the experience.* (N.W)
- *“ detailing the total cost for an entirely new manufacturing company was eye opening. ... If I were to ever start my own business, this is very useful course.”* (D.S.)
- *“I am really happy with the amount of material that I learned in this class.”* (R.B.)

5. Conclusion

The proposed curriculum had student progress through key steps that are required when pursuing a new idea and starting a new business. Those steps range from the development of new product or service to the design of the facility and floor plan and the determination of the numbers of machines and workers that are required. As the last step of this course, students were required to complete a PowerPoint presentation that represented a business plan and was reviewed by a peer who was acting as a loan officer.

Based on students' reflections and individual comments, it is determined that this course greatly benefited the students as it helped them develop an entrepreneur mindset. It also introduced students to key steps and tools that are required when starting a business. It is the authors hope that a full scale outcome assessment instrument will be developed in the future when the course is offered, and the outcome evaluation will provide more in depth evidence to show that such a hands-on course indeed advances students' entrepreneurial mindset.

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