

2006-2137: ENTREPRENEURIAL DESIGN PROJECTS: WHAT TYPE OF PROJECTS ARE EFFECTIVE IN IMPROVING STUDENT LEARNING & ENTHUSIASM?

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Entrepreneurial Design Projects: What Type of Projects Are Effective in Improving Student Learning & Enthusiasm?

Abstract

At Penn State's Entrepreneurship Minor, we have been experimenting with various types of design projects for the last three years in two courses: Engineering Design Principles (QMM 492), and Entrepreneurial Leadership (ENGR 310). In this paper, we review our experience regarding the implementation of these projects in the Entrepreneurship curriculum, and provide an assessment encompassing student learning, motivation, and entrepreneurial achievement. We have implemented and studied the effectiveness of the following types of projects: 1) need based conceptual design projects, 2) design and build projects, and 3) build and sell projects. Overall, preliminary results indicate that while all the included project types were perceived to be effective, the most effective one is identified to be the build and sell type, which more comprehensively simulates entrepreneurship.

Introduction

Shorter product life cycles and the trend toward mass customization are placing increasing demands on design practitioners and entrepreneurs. In addition, competitive pressures lead to less time spent by designers in traditional mentorship and apprenticeship methods of practice. Therefore, less-experienced designers are being given more responsibility for a larger number of design tasks¹. Yet mostly these designers are not well prepared to undertake these responsibilities. Accordingly, the demands from industry regarding this issue influenced the current ABET criteria. The current criteria for accreditation state that "engineering programs must demonstrate that their graduates have: an ability to design a system, component, or process to meet desired needs," and "an ability to function in multi-disciplinary teams."²

Multi-disciplinarity is mostly treated as having students with different engineering backgrounds in a design team (e.g., one mechanical engineer, and two industrial engineers). In industry, however, product design teams also involve individuals with non-engineering backgrounds such as law, business, industrial design, etc. Our graduates are rarely prepared to effectively perform in such environments due to a lack of experience with true multidisciplinary teams. At the Pennsylvania State University (Penn State), our response to this need is twofold: (1) the Master of Manufacturing Management degree program; and (2) the Engineering Entrepreneurship Minor. These curricular programs provide the opportunity for our graduates to complete product designs in true multi-disciplinary teams by utilizing strengths of the students coming from engineering, business and science backgrounds. This educational set-up also provides cross-training opportunities for our graduates.

To date, in both of the above mentioned programs the following types of projects have been incorporated to the curriculum in Entrepreneurial Leadership (ENGR310) or Engineering Design Principles (QMM492) courses since fall 2003:

- 1) Need based Conceptual Design Project** (examples are provided below):

- a. ***Making Life Better Before, During, and After Natural Disasters:*** Analyze the current offerings in the market and design a product that would make life better for those who lived through a hurricane disaster.
 - b. ***Electric toothbrush redesign project:*** Modify an electric toothbrush project after dissecting it for specific needs of a target population (e.g., kids, people with disabilities).
 - c. ***Improving the working life/environment of people with disabilities:*** Analyze the current offerings in the market and design a product that would make life easier/better for people with a specific disability.
- 2) **Design and Build Projects** (examples are provided below):
- a. ***Design/build a floor/desk lamp:*** Build a desk lamp that can be converted to a floor very easily using materials with a total cost of \$100 or less.
 - b. ***Aid Africa Project:*** Design a product that can help remedy/alleviate a problem for an under-privileged community (e.g., aiding people with the Guinea worm in Africa or earthquake victims in Pakistan).
- 3) **Build and Sell Projects** (examples are provided below):
- a. ***Cardboard product project:*** Build a product made of cardboard and sell to the students and faculty on campus and to the community (\$100 seed money is provided).
 - b. ***Product portfolio:*** Design, build and sell products that include at least one service, one tangible product, and at least one of the offerings is for elderly (\$100 seed money is provided).

This paper aims to shed light to one of the most important aspects of these programs: design projects, and their handling within the curriculum. The overall goal of the paper is to provide guidance for institutions with similar programs.

Assessment Planning and Application

With several years of experience in using project-based learning in the curriculum, and having adopted the above explained types of projects to teaching and learning, an instrument for assessing the effectiveness of different types of projects was designed and used for this study. The assessment instrument is presented in the Appendix. In this paper we present the preliminary data set collected using the instrument and its analysis.

The last question of the instrument was quantitative, and assessed three primary issues regarding the included project types:

1. How effective was the project in creating an environment for the students to learn?
2. How motivating the project was?
3. How effective was the project in providing a valuable experience in students' entrepreneurial development?

The remaining sections of the instrument included open-ended questions. Accordingly, content analysis was used to analyze the results. Content analysis has been defined as "any technique for making inferences by objectively and systematically identifying specified characteristics of messages,"³ or a systematic, replicable technique for compressing many words of text into fewer

content categories based on explicit rules of coding^{4,5}. In order to allow for replication, the technique can only be applied to data that are durable in nature.

In general, content analysis is used to examine trends and patterns or monitor shifts in documents⁶. It can be conducted simply by doing a word-frequency count. The assumption made is that the words that are mentioned most often are the words that reflect the greatest importance. However, during the word count usage of synonyms should be taken into account⁵. Content analysis results in data categorization. A category can be described as “a group of words with similar meaning or connotations”⁵.

Content analysis can be completed in two ways: 1) emergent coding, and 2) a priori coding. In emergent coding, categories are established following a preliminary data examination. Haney et al.⁷ suggest that first two people independently review the material and compile a set of features that form a checklist to be compared and reconciled. Then, they should use the consolidated checklist to independently apply coding. When a priori coding is selected, the categories are established prior to the analysis based upon some theory⁵. In either case, however, reliability of the coding (a 95% agreement is suggested; .8 for Cohen's kappa⁷) should be checked. If the level of reliability is not acceptable, then the coding should be repeated. Reliability is checked to ensure stability (can the same analyst get the same results try after try?), and reproducibility (or inter-rater reliability; does the coding check list lead to the same text being coded in the same categories by different people?).

According to Krippendorff⁸, six questions must be addressed in every content analysis: 1) which data are analyzed? 2) how are they defined? 3) what is the population from which they are drawn? 4) what is the context relative to which the data are analyzed? 5) what are the boundaries of the analysis? and 6) what is the target of the inferences? In this study, the questionnaire data collected from graduates of Entrepreneurial Leadership (ENGR310) and Quality Manufacturing Management (QMM492) courses between fall 2003 and fall 2005 were analyzed. The analyzed data consisted of the open-ended responses to 11 questions. The questionnaire was sent to students through their Penn State e-mail account. There was a cover letter which explained why we were collecting the data. Below we present the content analysis for the open-ended responses in addition to the quantitative responses.

Results

So far 15 responses have been received from students with varying majors. Major/minor and course completion of the respondents is provided in Table 1. The emergent coding was applied to the collected data as explained above. Below we present the questions and analyzed responses in order of appearance in the instrument.

1. Outside the classroom: What experiences have you had in a job, organization, or other activity that you found yourself using skills or knowledge that you gained in the entrepreneurship classes?

The entrepreneurship classes are structured as follows: 1. interdisciplinary teams are formed, 2. a leader is chosen (which rotates each project), 3. the instructor identifies a problem/project, 4. the team is left to create a solution within a given time frame, 5. the team presents to the class through a business plan or a PowerPoint presentation. Given the knowledge of this structure, leadership skills were the most commonly mentioned skills that students found themselves using

outside of the classroom. Due to the nature of the class projects, only those who volunteered to be leaders would have the opportunity. Of those who became leaders, they set their own goals, schedules, and method of holding each other accountable. Once the problem was given to the team, they worked to create a solution to the problem. The experience of working in interdisciplinary teams taught the leaders how to identify each team member's assets and utilizing them in order to create the ultimate solution. Several students gained skills and knowledge from the projects that helped them to make improvements to routine operations at their first jobs out of college. This further reinforces the long-term benefits of the projects. Below are the most frequently used word groups found in responses: Goal setting, improvements to routine operations, utilizing team members, and defining needs and creating a solution to the problem.

Table 1. Major/Minor and Course Completion Information for Respondents

Major	Minor	Courses Completed	
finance	engineering entrepreneurship	ENGR310	
civil engineering	engineering entrepreneurship	ENGR310	
finance	engineering entrepreneurship	ENGR310	QMM492
recreation park mgmt	engineering entrepreneurship	ENGR310	QMM492
finance	engineering entrepreneurship	ENGR310	
computer engineering	engineering entrepreneurship	ENGR310	
finance	engineering entrepreneurship	ENGR310	
finance	engineering entrepreneurship	ENGR310	QMM492
operations and systems management	international business		QMM492
computer science	engineering entrepreneurship	ENGR310	
master of manufacturing			QMM492
information science technology		ENGR310	
no answer	no answer	ENGR310	
accounting	engineering entrepreneurship	ENGR310	QMM492
finance	engineering entrepreneurship		QMM492

2. Inside the classroom: What did you like the most about these courses?

In general, each project was treated as a competition within the class, and the winning teams would have the chance to present at the Entrepreneurial Design Competition. The instructor gave every team the same problem, which forced the members to think creatively in order to come up with the best solution. In addition to creating an idea, each team also had to create the product or prototype; and in most instances they actually attempted to sell the product. These trends were captured in the following selected quotes from the responses: “The best thing about these classes is that they aren’t straight lectures, where you sit in a big room, take notes, and take exams. I liked the fact that we did a lot of group work and we worked on real world projects. There was always an opportunity to turn our class work into a money making venture.” “Challenged to think creatively and put ideas into action.”

The most frequently used word groups provided in responses were: finding creative solutions to society’s problems, leadership opportunities/experience, and teamwork.

3. Which project was your favorite? Specifically, what things did you learn from this project?

Most frequent responses to these questions included build and sell projects, and the product portfolio. The following quotes taken from student responses, below, expand on these: “I liked the final project where we had to make money. We got to see first hand the kind of problems encountered when developing a product, and find quick and efficient solutions for each problem.”

“The project that I have learned the most from is one that I am currently working on. A student had contacted me via the e-ship program about a vision that he had. It was an idea that he and a professor in ESHIP had been juggle with for a few years. I thought about the idea critically and realized that in its current form that it would never reach the market. After researching and revising the vision and finding the perfect confluence of market and technology, I believe now we have created a great business model. I first began researching and developing this idea in June 2005. Since then we have filed two provisional patents, honed our business model, established ties in industry and academia, and incorporated. We took the idea to the International Idea to Product Competition in U. Texas and will take it on the road at the MBA level this spring. We have applied for over 300K in grant funding. Ideally I want to transform this entrepreneurial vision into a world class organization. The knowledge gained from the project is almost immeasurable. We have covered practically every facet of business.”

4. Which project motivated you the most? Why?

Overall, responses indicated that the leadership role really motivates students to put much effort into the organization, stimulation, and execution of their individual teams. When put into these situations the students don't want to lose to the in-class competition and they feel responsible for the actions of their teammates. From the given set, build and sell projects, and design and build projects were found to be more motivating compared to others. The following quotes reflect this: “The build and sell project motivated me the most, because it was very open-ended and had the most competitive atmosphere. The ability to make money while doing class work was great.”

“My group attempted to make an interactive map for State College. There were 12 people in my group and I was the leader. It was very difficult to manage 12 people; I learned the importance of organizational leadership through this experience.”

5. Which project gave you the biggest sense of entrepreneurial achievement? Why?

Once again, the responses converged on build and sell, and design and build projects. The evidence of this is seen in the following quotes: “Build and sell, because we were actually promoting something outside the classroom. Our achievement was based exactly on how those outside the classroom perceived our product. It tested exactly how strong our entrepreneurial spirit is/was.”

“We were able to almost start from scratch and pull in over 3 thousand dollars in a little over a month.”

6. What aspect of the classes was most difficult to you? (Solidworks, conceptual design, teamwork, etc.)

As part of the QMM 492 class, a solid modeling software is introduced to aid in form design of products. When asked this question, students with predominantly non-engineering backgrounds

indicated Solidworks learning to be the most difficult part. “Solidworks without a doubt was tough. I am a finance major and had no prior experience with Solidworks.”

7. What have you learned from creating a Business Plan?

The quote, “I learned just how in depth and well planned your ideas need to be in order to be successful in business. There are so many angles to look at and different scenarios to be prepared for if you don’t want to fail.”, indeed voices the overall agreement. The most frequently used word groups provided in responses were: the amount of detailed sections, and understanding the business model.

8. What skills or knowledge that you took away from the classes do you value the most?

While the responses for this question varied immensely as seen in the following quotes, two emerging foci are identified as creating problem solving, and the comprehensive knowledge on how to turn an idea into a business venture.

“Tools, such as AHP, morphological chart, TRIZ, method 6-3-9, etc, which we can support our decision making and results.” “I would say the things I value the most are the relationships I established with people within the Entrepreneurship Program.” “The confidence in knowing that my ideas can be successful, and that I can take a concept and develop into a product.”

9. Upon completion of the classes, do you see yourself as more likely or less likely to become an entrepreneur?

Overall, the responses indicated that students felt more likely to become entrepreneurs.

10. One of the unique aspects of these classes is that the teams are comprised of students from all majors (Engineering, Business, IST) in varying academic levels. What did you learn the most from the diversity within the teams?

Responses converged on an appreciation of diverse educational backgrounds, and how to communicate to maximize the team outcomes. Evidence of this can be seen in the following quotes: “That everyone has different strengths and weaknesses. Capitalize on the strengths and don’t make anyone do something they’re not good at doing. If the team has many different strengths then they will compliment each other in one great group.” “The diversity within my teams allowed me to appreciate the intelligence of other majors. It provided me with an opportunity to see what type of education they are receiving.” “How to communicate when not everyone has the same depth of knowledge in specific areas. Also, being able to play your strengths while others play theirs really is a nice complement to the group.” “I learned the different perspectives of different majors and how they can all collaborate to perform a task. I also understand that it is necessary for effective communication to occur between these different perspectives in order for a entrepreneurial idea to be successful.”

11. Final comments?

When asked for final comments students gave their overall view about the entrepreneurship courses, which is mostly positive: “This minor is one of the most enjoyable and most valuable experiences of my college career.” “Yes, the Minor has exceeded expectations so far, and the staff are tirelessly helpful in helping entrepreneurial efforts outside of classes as well; I really can’t say enough about them.”

Table 2 summarizes the responses to question 12, which was quantitative in nature. Results of the analyzed preliminary data indicate that in all three issues build and sell project has been the most effective.

Table 2. Effectiveness Ratings for Various Project Types

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	N/A
a. The Need based Conceptual Design Project I have completed created an environment for me to learn how to design products in support of related entrepreneurial endeavors.	20%	67%	07%	00%	00%	07%
b. The topic of the Need based Conceptual Design Project was motivating .	07%	60%	07%	20%	00%	07%
c. I find the Need based Conceptual Design Project to be a valuable experience in my entrepreneurial development.	20%	47%	27%	00%	00%	07%
d. The Design and Build Project I have completed created an environment for me to learn how to design products in support of related entrepreneurial endeavors.	27%	20%	13%	00%	00%	40%
e. The topic of the Design and Build Project was motivating .	07%	33%	07%	13%	00%	40%
f. I find the Design and Build Project to be a valuable experience in my entrepreneurial development.	20%	27%	07%	07%	00%	40%
g. The Build and Sell Project I have completed created an environment for me to learn how to design products in support of related entrepreneurial endeavors.	20%	27%	07%	07%	00%	40%
h. The topic of the Build and Sell Project was motivating .	33%	20%	07%	07%	00%	33%
i. I find the Build and Sell Project to be a valuable experience in my entrepreneurial development.	47%	07%	07%	07%	00%	33%

Results indicate that eighty-seven percent of the students agreed/strongly agreed that the Need based Conceptual Design Project created an environment for learning how to design products in support of related entrepreneurial endeavors. Sixty-seven percent agreed/strongly agreed that the topic was motivating, while twenty percent disagreed. Sixty-seven percent found the project to be a valuable experience in their entrepreneurial development. Likewise, forty-seven percent of the students surveyed agreed/strongly agreed that the Design and Build Project created an environment for learning how to design products in support of related entrepreneurial endeavors. Forty percent felt agreed/strongly agreed that the topic was motivating, while thirteen percent disagreed. Forty-seven percent agreed/strongly agreed that the project was a valuable experience in their entrepreneurial development. Finally, forty-seven percent of the students surveyed agreed/strongly agreed that the Build and Sell Project that they completed created an environment for learning how to design products in support of related entrepreneurial endeavors. Fifty-three percent felt that the topic was motivating, while seven percent disagreed. Fifty-four percent agreed/strongly agreed that the project was a valuable experience in their entrepreneurial development.

When the data in Table 2 are arranged in a way to exclude the “not applicable” responses, the overall quantitative effectiveness values are achieved, which are presented in Table 3.

Table 3. Which Project Type Is More Effective?

Course(s) Completed	Conceptual Design Project			Design and Build Project			Build and Sell Project			
	a	b	c	d	e	f	g	h	i	
ENGR310	5	5	5	5	4	5	5	5	5	
ENGR310							5	5	5	
ENGR310	QMM492	4	2	3	4	3	4	4	5	
ENGR310	QMM492	4	4	4	4	2	4			
ENGR310		4	2	3			4	4	4	
ENGR310		4	4	5			4	4	5	
ENGR310		4	4	3			5	5	5	
ENGR310	QMM492	3	2	3	3	4	3			
	QMM492	5	4	4	5	4	5			
ENGR310		4	4	4			4	5	5	
	QMM492	4	4	4	5	4	5	5	5	
ENGR310		4	4	4	3	2	2	2	2	
ENGR310		4	4	4						
ENGR310	QMM492	4	3	4	4	4				
	QMM492	5	4	5	5	5	4	3	3	
		4.14	3.57	3.93	4.22	3.56	4.00	4.33	4.20	4.40

Results in Table 3 indicate that out of the three different types, build and sell projects are perceived to be the most effective. In general, however, all the project types were seen to be effective in creating a good learning environment and providing a valuable experience. However, the topics of the conceptual design and design and build projects should be better selected to improve motivation.

Conclusions

In this paper, we have studied the effectiveness of three types of projects: 1) need based conceptual design projects, 2) design and build projects, and 3) build and sell projects. Overall, preliminary results indicate that while all the included project types were perceived to be effective, the most effective one is identified to be the build and sell type, which more comprehensively simulates entrepreneurship. The data presented in the paper are deemed preliminary because of the size of the data set. Future papers regarding this work will include a larger data set as well as reliability analysis results.

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Appendix – Survey Instrument

Major:

Minor :

Please list the E-ship course you have completed:

1. Outside the classroom: What experiences have you had in a job, organization, or other activity that you found yourself using skills or knowledge that you gained in the entrepreneurship classes?
 2. Inside the classroom: What did you like the most about these classes? What would you like to see improved?
 3. Which project was your favorite? Specifically, what things did you learn from this project?
 4. Which project motivated you the most? Why?
 5. Which project gave you the biggest sense of entrepreneurial achievement? Why?
 6. What aspect of the classes was most difficult to you? (solidworks, conceptual design, teamwork, etc.)
 7. What things did you learn from creating a Business Plan?
 8. What skills or knowledge that you took away from the classes do you value the most?
 9. Upon completion of the classes, do you see yourself as more likely or less likely to become an entrepreneur?
 10. One of the unique aspects of these classes is that the teams are comprised of students from all majors (Engineering, Business, IST) in varying academic levels. What did you learn the most from the diversity within the teams?
 11. Do you have any final comments?
12. Please indicate your degree of agreement with the following statements by putting an “X” in the cell in the cell that corresponds to your agreement level:

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	N/A
a. The Need based Conceptual Design Project I have completed created an environment for me to learn how to design products in support of related entrepreneurial endeavors.						
b. The topic of the Need based Conceptual Design Project was motivating .						
c. I find the Need based Conceptual Design Project to be a valuable experience in my entrepreneurial development.						
d. The Design and Build Project I have completed created an environment for me to learn how to design products in support of related entrepreneurial endeavors.						
e. The topic of the Design and Build Project was motivating .						
f. I find the Design and Build Project to be a valuable experience in my entrepreneurial development.						
g. The Build and Sell Project I have completed created an environment for me to learn how to design products in support of related entrepreneurial endeavors.						
h. The topic of the Build and Sell Project was motivating .						
i. I find the Build and Sell Project to be a valuable experience in my entrepreneurial development.						