Enhancing the Product Realization Process by Emphasizing Innovation and Entrepreneurship
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Abstract
This paper outlines the experiences at the School of Engineering at the University of Dayton in implementing the Product Realization Process (PRP) in industry-sponsored capstone team design projects with an emphasis on innovation, entrepreneurship, and developing business plans. Particular emphasis is placed on the incorporation of innovation and entrepreneurship since the Innovation Center was established four years ago. In 1996, we began using the PRP in engineering capstone courses with eleven projects from four companies. We now implement over eighty projects each year from approximately forty companies annually. The total number of companies that have sponsored projects is now over 100. Approximately thirty capstone projects per year are related to innovation and entrepreneurship and include elements of market studies, intellectual property investigations, cost estimating, manufacturing, and the development of a business plan. This paper will address the following:

- The enhancement of the conceptual design process to emphasize innovation and ideation.
- The migration from a single capstone course to multiple courses in several years across the curriculum that instill an entrepreneurial mindset in all engineering students, as identified in our Kern Entrepreneurship Education Network (KEEN) mission.
- The development of partnerships with faculty and students in the School of Engineering, the School of Business, and the Law School with an emphasis on innovation and entrepreneurship.
- The multidisciplinary nature of the projects with parallel phases that include the demonstration of technical feasibility and the development of a business plan.

Introduction
Traditional design practices have been replaced in companies by concurrent engineering practices. One approach has been referred to as the Product Realization Process (PRP) and includes determining
First, we want to raise the level of consciousness of innovation and entrepreneurship in engineering with our faculty and students. This is a cornerstone of our commitment to the Kern Foundation, and the university.

Second, as outlined by Tim Kriewall (5), the KEEN Pyramid involves four major areas. These include technical fundamentals, customer awareness, business acumen, and societal values. These cannot all be achieved in one course but are the values we seek to promote across our curriculum.

Third, we strive to be one of the premier innovation centers associated with both undergraduate and graduate programs in a university environment.

Fourth, it would be advantageous if all entrepreneurs that had successful projects were able to find capital and form a business. However a stronger objective is to instill the four (KEEN) attributes of
an entrepreneurial engineer, thereby developing the complete professional.

In this paper we describe our approach and where we stand on achieving our vision and goals.

The Evolution to Include Innovation and Entrepreneurship

The Design and Manufacturing Clinic (DMC), formed in 1996, is a formal organization in the School of Engineering whose function is to obtain sponsored projects and find a venue for projects within the curriculum (Doepker 1999). A design project agreement was developed to protect the confidentiality of information for the sponsor as well as address the intellectual property rights. The sponsor retains all rights to the intellectual property rights.

To amplify and enhance the DMC experience, it was decided that the clinic capstone experience would expand to include projects that were more innovative in nature and which could possibly be marketed. We had several projects for which entrepreneurs named students in patents. We wanted to make that type of experience more formal. Thus, we have modified the design project agreement whereby the university would share in the profits and sales of products while the entrepreneur maintains the intellectual property rights. Support for projects that could not be provided by entrepreneurs has been obtained from a portion of the Kern Family Foundation KEEN Grant.

Project proposals are presented to the faculty and students during the first week of class. Students rank the projects in the order of greatest interest. Teams are then formed based on student project interest. There are at least two project mentors, one from industry and one a member of the faculty. We have now included faculty mentors from the Management and Marketing Department in the school of Business Administration. As part of the KEEN grant, the PI and the KEEN Fellow work closely to combine technical feasibility and the development of business plans on entrepreneurship projects. Thus, students from the entrepreneurship program in the School of Business Administration (SBA) have joined with engineering students to develop business plans. Typically, this means that there will be three or four engineering students and two entrepreneurship students making up a multidisciplinary team.

Innovation and Entrepreneurship Throughout the Curriculum

The course sequence (Figure 2) can best be visualized by a flow diagram that shows the interrelationship between the stages of the design process at various levels. In this figure, there are four courses that span the four-year engineering curriculum. Each will be described individually.

![Figure 2. Design and Innovation Course Sequence](image)

The first year experience

The engineering innovation course (EGR 103) is an introductory class to Innovation and Design. This class incorporates a number of important aspects that will be of benefit to the student throughout their engineering coursework. In this class sequence social responsibility, environmental issues, and the product realization process are emphasized. Early in the course, the students take the Myers-Briggs Test to determine not only their own personal traits, but also how to deal with others. A psychologist spends one
class period reviewing the different characteristics of each type and how differences can enhance a team. Before the team projects begin, an entrepreneur and business plan expert from Eureka Ranch! in Cincinnati provides a presentation on brainstorming, ideation and team effectiveness. This is followed by a fun team-building exercise. The first is a two-class sequence to design a simple device like a cardboard chair. The second project requires over six weeks to design a socially responsible device or system as selected by the instructor.

Upper level design

As part of the design sequence, a new course (EGR 433) has been implemented to emphasize innovation and entrepreneurship. Topics include project management, time value of money, cost estimating, business plans, and intellectual property. The focus of this course has changed since we have obtained the KEEN grant. With support from the KEEN grant and the entrepreneurship program, we have been expanding the entrepreneurial knowledge and mindset of engineering students. This has been accomplished by having the KEEN Fellow and another faculty member from the entrepreneurship program lecture on the organization of business plans and what investors are seeking. Faculty from the law school and local practicing patent attorneys have been guest lecturers that have addressed intellectual property, litigation, and the development of provisional and full patents.

The Product Realization Process (PRP) (Pugh 1990; Doepker 1999) is the approach used in all of the design project courses: EGR 103, 431 and 432. Nearly all of the projects have an external client, especially those that come later in the curriculum. The major areas of the PRP are:

1) Establishing the need with the client.
2) Developing the specifications and writing a proposal. This includes the functional requirements, the design requirements, and design criteria.
3) Based on these guidelines, the individuals generate concepts and bring their ideas to the team for consideration. The top candidates undergo a decision analysis.
4) The decision analysis establishes the embodiment design. This is where a feasibility analysis and feasibility tests are performed. In Figure 1 above, this is the end result in the one-credit class. It’s here that the project may be continued and where the final design, build, and prototype testing occurs.
5) This embodiment design is followed by the final design, analysis, and testing.
6) The final step is the implementation of the design that will potentially result in its combination with a business plan to provide a new product through entrepreneurship.

The above process has been enhanced in the curriculum by partnership with the individuals in the School of Business Administration, the Management and Marketing Department, and the Entrepreneurship Program. With the strong foundation that has been built over a decade of industry-sponsored projects in engineering and an entrepreneurship program that is ranked fourth in the country by The Princeton Review, a strong collaboration has been established. We are continuing to strengthen this alliance through multidisciplinary teams that design and build products that, along with a strong business plan, can be the basis for an entrepreneurial enterprise.

Implementation of the PRP

The first phase of the PRP (Figure 1) involves the establishment of needs and the generation of ideas. Design or redesign takes place because a need exists. After the needs are established, the specifications are generated. Specifications are classified in three categories: Functional Requirements, Design Requirements, and Design Criteria. The functional requirements are general in nature and identify what the design is
required to do. The design requirements specify how it is to be done and provide actual quantitative values for some of the constraints (e.g., horsepower requirements, type of electric service). The design criteria address the guidelines to which the design must conform, outlining to what degree issues such as safety, cost of the system, ergonomics, aesthetics, materials, performance, size, etc. must be satisfied. The criteria or guidelines are similar to those presented by Pugh (1990). When the specifications are identified, the teams must define the deliverables. In previous semesters this would conclude the first phase of the PRP. However, with innovation projects where a new product is developed, two new dimensions have been added. First, the students must perform patent searches based on the functional and design requirements to determine if the same or similar devices exist. In addition the market (potential) must be established. Frequently an entrepreneur will identify that this is the “greatest invention” but have very little knowledge about whether it will sell. In other cases, the entrepreneur will state that they have conducted informal surveys and found a very high level of interest. It is now up to the student team to determine if the product/project has feasibility from a market standpoint. This concludes the first phase as listed in Figure 3.

Conceptual Design and Decision Analysis

The conceptual design phase is arguably the most critical part of the process. It is in this early stage of the process where the greatest flexibility exists and corresponds to the lowest cost impact for design changes. It is also the phase that students struggle with because it requires design synthesis and not closed-form solutions. As part of the conceptual design process, each individual on the team generates three conceptual designs. These concepts are based on knowledge obtained in prerequisite courses such as Theory of Machines, Design of Machine Elements, and Mechatronics. It is expected that students will be familiar with mechanisms like power screws, hydraulic and pneumatic cylinders, and general torque transmitting components. The initial concepts are presented through both sketches and a narrative of how it will work and major design characteristics. Team members perform a linear-weighted decision analysis (Pugh 1990) on their designs as correlated with the design requirements and design criteria developed under the specifications. Other decision analysis techniques such as controlled convergence (Pugh 1990) have been used at the discretion of the faculty mentor and professor. Pahl and Beitz (1996) present other popular methods. Individual team members assemble to discuss their designs and decision analysis, and the higher rated designs are further scrutinized and a team decision analysis is performed. Frequently this will result in a hybrid design that incorporates ideas from several designs. The results of the team collaboration are then presented to the sponsor for feedback at an oral presentation. Included with this presentation is an outline of the deliverables. As discussed in detail later, frequent communication with the sponsor is a key to meeting the goals for the project. Based on sponsor input and team decisions, one design is carried forward with several others placed on hold for contingency purposes. A Gantt chart (similar to Figure 3) is prepared, providing a schedule for the activities for the term.
Figure 3. Gantt Chart - General Product Realization Process

**Embodyment Design**

The concept that has been selected becomes the focus of embodiment design in preparation for the final design. Pahl and Beitz (1996) identify that “during the embodiment phase, when the layout and form design of the...concept is first quantified, both the objectives of the task and also...task-specific constraints must be considered.” In this phase, the materials to be used, as well as the geometry, are more clearly defined. Early in this phase, a detailed drawing is generated (without dimensions) that articulates the relationship between individual components. One function of this drawing is to itemize the parts required for the final design. It is from this that the team determines the engineering calculations that must be performed to adequately analyze the design. Team members are assigned to perform the calculations and choose whether to use the original design or mass-produced components and systems. When the Gantt chart is updated, iteration occurs. All of this is provided to the customer in the form of a written status report and an oral presentation, which is frequently used as a method of performing a mid-course correction and assuring the deliverables will be met.

In this phase, the bill of materials and the design becomes clearer. It is with this information that the team and the sponsor can approach a manufacturer to obtain an estimate regarding the cost of fabrication. This communication now serves as input to the financial portion of the business plan. The cost to fabricate can

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<th>SCHEDULE</th>
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<tr>
<td><strong>MONTHS</strong></td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td><strong>Activity</strong></td>
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<tr>
<td>Establish Need</td>
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<td>Design Criteria</td>
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<td>Identify Deliv.</td>
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<td>Conceptual Design</td>
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<td>Team Specs</td>
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<td>Decision Analysis</td>
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<td>Oral Presentation</td>
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<tr>
<td>Dev. Gantt Chart</td>
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<td>Embodiment Des.</td>
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<td>Develop Engr Draw.</td>
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<td>Develop Parts List</td>
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<tr>
<td>Identify Calculation</td>
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<tr>
<td>Oral Presentation</td>
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<tr>
<td>Final Design</td>
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<tr>
<td>Select Components</td>
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<td></td>
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<tr>
<td>Design Components</td>
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<tr>
<td>Perform Analysis</td>
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<tr>
<td>Cost Estimate</td>
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<tr>
<td>Engr. Draw. (CAD)</td>
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<tr>
<td>Write Narrative</td>
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<tr>
<td>Submit Final Report</td>
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<td>Final Oral Pres.</td>
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In this phase, the bill of materials and the design becomes clearer. It is with this information that the team and the sponsor can approach a manufacturer to obtain an estimate regarding the cost of fabrication. This communication now serves as input to the financial portion of the business plan. The cost to fabricate can
be used to determine the final purchase price, which in turn can be used in surveys to understand the voice of the potential customer.

**Final Design**

The overall design, completed in the embodiment design phase, becomes the design on which engineering calculations are made. Detailed analyses that were previously considered “design” (stress analysis, shaft design, heat transfer, design for manufacture, etc.) are performed in this phase. The importance of individual effort and accomplishment outside of team meetings is stressed. Engineering drawings are developed that will eventually be used by the sponsor or other student design teams. In most cases, the sponsor implements some or all of the design. In other cases, projects are carried over from one semester to another, and a design that was developed in one semester is manufactured in the next. The project concludes about fourteen weeks after it was begun, with a detailed final report and a one-hour formal presentation to the sponsor.

When the prototype is fabricated, it can now be used as a model in focus groups, which provide valuable insight into how the product will be used and make recommendations regarding the functionality and ergonomics and other human factors. With the proper selection of focus groups, a projection can be made to identify the sales potential for the product. Again, this can be used in the business plan as an asset to seek venture capital. Also, now that the design has been better defined, it’s important that a competitor analysis also be completed. This will better define the market size estimates.

**Final Report**

A significant portion of the grade in this course is based on the final report and its contents. The report is similar to a report required from project teams in industry. Dym and Little (2005) present the importance and format for the final report and oral presentations.

The final report is provided to the sponsor at the completion of the project. The project is covered in detail in a narrative section where the team describes the need, specifications, conceptual designs, and the final design. The format reflects the PRP and includes the manufacturing sequence, operating procedures, a cost estimate, and engineering calculations. Conclusions and recommendations are provided that compare the results to the design requirements.

It has been our experience that beginning the business plan when the design has been finalized does not work. It is important that the business plan be emphasized from the start. This is not to say that students should start writing the business plan from the beginning, but that they should be aware of the components of the business plan and build the case for the product. A team must be careful to address patent issues, technical feasibility, the potential market, Porter’s Five Forces, etc. Also, there are a number of factors that could be “show stoppers” that must be determined early. These could include a limited market, high cost of production, and infringement on patent rights.

**The Experience and Assessment**

Because of the increase in the number of mechanical engineering students and the increase in the number of departments participating in the Innovation Center and the Clinic, the number of projects has increased significantly each year. The number of students involved with the senior capstone design experience has grown from sixty-five in 1996-97 to 350 this past academic year.

At the conclusion of each project, the industry mentors/sponsors are asked to evaluate team performance. Over the past six years, 76% of the clients/mentors have said that the results have been significant for them. Twenty-three percent thought that the results would be moderately helpful. A major area of interest
has been for the question that asks at what level the goals and deliverables have been met. Twenty-four percent said the goals were exceeded, while 62% said the goals had been met. Thus, 86% felt that the goals were either exceeded or attained. Thirteen percent thought that they were nearly met, while 1% said that teams failed to meet the goals. This can be seen in summary form in Table 1. We had an excellent year last year, as our overall average increased. (Exceeded gets four points, etc.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Exceeded (4)</th>
<th>Attained (3)</th>
<th>Nearly Met (2)</th>
<th>Failed (0)</th>
<th>Score</th>
</tr>
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<tbody>
<tr>
<td>03/04</td>
<td>6</td>
<td>26</td>
<td>2</td>
<td>0</td>
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<td>04/05</td>
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<td>17.5</td>
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<td>05/06</td>
<td>7</td>
<td>19</td>
<td>6</td>
<td>1</td>
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<tr>
<td>06/07</td>
<td>14</td>
<td>37</td>
<td>9</td>
<td>2</td>
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<tr>
<td>07/08</td>
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<td>08/09</td>
<td>20</td>
<td>24</td>
<td>2</td>
<td>0</td>
<td>3.3</td>
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</table>

Table 1. Sponsor Assessment – At what Level Were Goals and Deliverables Achieved?

**Why a Business Plan?**

Designers must understand the significance and importance of business plans. It is this document that must be used to convince investors that the entrepreneur is ready to move forward. It is especially important to understand and develop a business plan early, since many of the criteria for evaluating conceptual designs involve business-related issues. If one were to use Pugh’s criteria (1990), items such as patents, cost, market, and competitors would be important factors in judging individual conceptual designs. If there is an overlap with an existing product, decisions must be made to identify how the patent issues will be addressed. Also, if the cost is too high, the team must determine what can be done to bring costs in line. If you understand your competition, you can design your product relative to theirs and improve on their design.

The teaming of engineering and entrepreneurship students has resulted in a high success rate for these teams in the business plan competition. There are an increasing number of business/engineering teams entering the business plan competition every year. Two years ago, one such team finished in first place. Last year, although there were no first place finishes for business/engineering, these teams represented four of the top six teams and five of the top ten, out of about sixty participants.

**Elements of the business plan**

There are many models or templates that can be used to determine the major elements of a business plan. When our sponsor/entrepreneur asked a student team to write a business plan for a recently developed device, we decided to organize the project team into two groups. One group would concentrate on finishing up the technical design, including industrial design, functionality, and manufacturing. The second group would concentrate on writing the business plan. This second group (and the faculty) soon came to realize that we were not prepared to jump right in and write a business plan as one might write a proposal. We sought the help of the faculty in the School of Business Administration (SBA), thinking that all we would need to do was conduct a marketing survey and develop a cost estimate. We soon found there were numerous models that could apply, and that the more detail we had in the technical prototype
and in the business plan, the more successful the sponsor/entrepreneur would be in selling his/her ideas to venture capitalists and other lending institutions.

Thus, we set out to determine the document that would best fit our needs. The students sought references, and within twenty-four hours they had produced a document that looked like a simple approach, “Business Plans for Dummies” (Tiffany and Peterson 2005). A meeting with the faculty in the SBA identified several highly acclaimed references that could apply (Barringer and Ireland 2006). One member of our advisory committee produced an excellent document for this purpose written by Deloitte & Touche (2003). In reviewing these, we have relied on a modified approach provided by Dr. Diane Sullivan in a series of lectures that she has presented to our Project Management and Innovation one-hour class (2009). This is shown in the following sequence.

7) Cover Page
1) Table of Contents
2) Executive Summary
3) Description of the Business Opportunity
4) Description of the Industry and Competition
5) Description of the Target Market and Marketing Plan
6) R&D (if applicable) and Legal Actions Taken to Protect Technology
7) Firm Founding Location
8) Management
9) Financials
10) Payback/Exit Strategy
11) Critical Risks
12) Milestone Schedule (Gantt Chart)
13) Appendices

This paper will not go into each of these elements in detail. The purpose of providing this list is to show the breadth and depth that engineers, designers, and entrepreneurs must go to develop products and bring them to market.

Description of the business opportunity

The business plan should describe the opportunity for the product. This includes the need, and how the business will address the need. It’s important to define the product’s competitive advantage if there are offerings of other similar products in the market. A business model must be developed that should include how and where it will be manufactured. Sales methods must also be defined. Will it be sold on the internet or in retail establishments?

Description of the competition and industry

Under this heading, students address the factors that will enhance or limit the industry profitability. There is a standard set of terms that are used to define these issues called Porter’s Five Forces. This is a standard that venture capitalists and lending institutions look for, to determine the completeness of the offering. These include: (1) the power of the suppliers, like raw materials; (2) new market entrants; (3) buyer power, or how much bargaining power the customers have; (4) competition from rival organizations and its
intensity; and (5) threats from substitute products that will develop similar innovations.

Target market and the marketing plan
Who is the target market, and is it large enough to sustain the product? The market could be narrow and limited to a small percentage of the population. The design of a new ice skate sharpener would be smaller than the market for a new lighting control system for homes and businesses. However, there may not be any devices on the market to sharpen skates, while hardware stores have a proliferation of lighting systems. The marketing plan should be developed based on the target market, surveys, and focus groups. As described by Sullivan (2009), there are four Ps associated with marketing: (1) Person, whom are you targeting; (2) Pricing, how your offerings are going to be priced with respect to your competitors; (3) Promotion, or awareness of the product; and (4) Placement, where will it be sold?

Legal concerns
Offerings with a strong technical background should be analyzed in-depth for patent infringement and a patent applied for as soon as possible. Searches should be made at the US Patent Office (www.uspto.gov) or the Google search engine. The School of Law at the University of Dayton has become a partner in the development of our Innovation Center. Faculty in the School of Law has provided tutorial and seminars for engineering and business students. In addition, several projects have moved to the final stages of the patent process with the help of the law faculty.

Search and Research
Consultation with members of our industrial advisory committees and faculty has resulted in a list of reference materials related to new product development and entrepreneurship. These documents are listed in the reference section of this report.

Summary of Experience
Over the past four years, we have gained significant experience in innovation and new product development through experiential learning. Initially, we decided to take several projects that involved new product development and apply these to a business plan so the customer could use these to seek venture capital. This resulted in proof of technical feasibility but an incomplete business plan. Thus, we approached the faculty in the School of Business Administration (SBA) to form a new process with expert guidance. In parallel, we applied for, and were successful in obtaining, a Kern Family Foundation KEEN (Kern Entrepreneurial Education Network) grant. The benefits from the KEEN grant have been many. First, we have operated more effectively by sharing experiences with cohort colleges and universities. It has also facilitated the collaboration between the School of Engineering and the Entrepreneurship Program in the SBA. Funding has encouraged a dialogue between engineering and business students through the Collegiate Entrepreneurs Organization (CEO). The grant has also provided the resources for us to implement projects that might not have been funded previously. Finally it is raising the awareness of innovation and entrepreneurship for both students and faculty. The newly appointed dean of the School of Engineering presented in his address to the faculty that entrepreneurship and innovation were paramount objectives for the school. In addition, he has agreed to work with all departments to include components of innovation and entrepreneurship in the curriculum.

Examples of projects that have done well in the business plan competition that potentially could be the basis for a new business include:

1) Math Manipulatives: A mechanism (hardware) that can be adjusted to form all seven quadrilaterals and can be used by math teachers to demonstrate in class.

2) LED Light Cones: Low cost, low energy light cones that can be used for emergency vehicles.

4) The design of a knee brace for patella alignment to assist people with physical challenges.

Other projects/products that are being pursued by industry sponsors with design students listed as a part of the patent include:

1) Remote sensing device to determine temperatures of items in an oven.

2) Design of a heat exchanger to reduce energy losses in industrial dishwashers.

3) Design of an adhesive product that will mix epoxy and hardener in a closed container.

4) Design of a medicine (pill) dispenser for distribution of medication using a computer and controlled remotely. Patents were received and students have been recognized by name.

Conclusions
Our objectives in expanding the collaboration between engineering and entrepreneurship were articulated in the introduction section of this paper. The following represents our progress toward achieving these goals:

1) Our sponsor evaluations were outstanding, with over 85% of the respondents indicating that we met or exceeded our goals and deliverables. This has also shown continual improvement.

2) As the result of the strong collaboration, we are one of the premier undergraduate programs to include solid technical fundamentals with a strong business acumen, which is developing excellent entrepreneurial engineers. The indicators are:

a) The head of the SUCCEED Coalition (NSF) has stated that the University of Dayton program is a “shining example of design leadership, especially as it relates to recruitment of projects, resources, and collaboration with industry. Qualitatively, I would place this program in the top 10% of those I visited.”

b) Based on feedback from the Design Engineering Division of ASME, Dayton has one of the best design programs implementing a broad range of business- and industry-sponsored projects.

c) The leaders of the Kern Foundation have held this program in high regard and use it as an example for other cohort institutions. Presentations are given regularly to faculty in the cohort schools, state schools (Ohio State), and other universities in the Midwest.

d) Industry leaders regularly sponsor projects and seek our graduates based on the students’ work in design teams.

4) We have visited some of the top schools in the country that run design projects (Harvey Mudd, Olin, etc.) and have found that our design program is comparable. This coupled with the fact that engineering students and faculty are able to work with entrepreneurship students and faculty that are listed as fourth in the country, shows that this is a program and an approach that is hard to match.

5) The program described above has had many successes in terms of projects and designs that have great potential for future business opportunities.

6) The incremental approach that we pursued has served us well since 1996.

Lessons Learned
The following represents some of the lessons learned over the past several years:
An engineering team should not write a business plan on their own, unless they have had several courses that deal with business plans.

Any student team that develops a business plan should well versed in market analysis, patent searches, market surveys, cost estimates, and the manufacturing enterprise.

A complete prototype gives the sponsor/entrepreneur a significant advantage in presenting a business case (Business Plan Competition) for seeking financial support. Venture capitalists want to know that the product has been designed, built, and tested.

Team members (business and engineering) need to work together from the beginning of the semester and not join later in the term.

The business aspects should be addressed early in the product development cycle. We waited until we had a working prototype before we started the business plan on one project. These need to run in parallel.

Once the final design is complete, a prototype built, and a business plan is complete, the sponsor is ready to move onto the next step. Frequently the sponsor is unable to do this and has difficulty seeking venture capital and finding a manufacturer. Patents should also be pursued. Often the client is still not finished and perhaps needs the help of an incubator.

Seek input from community development or entrepreneurship agencies. Find out how successful businesses have developed their plans.

Conduct patent searches as part of the conceptual design process. In this way some concepts could be eliminated simply based on patent infringement.

Know that it will take between three to six years in an academic environment from the time a new project/product is proposed until it will get to market.

Difficulties arise when a project goes from one term to another and people from the original team are not the same throughout. There is a learning curve each semester.

If a program requires input from a sponsor and is able to fund the project internally, then there are costs associated with the project and materials as well as displacing “paying” projects from other sources. Thus, one should understand the difference between industry-sponsored projects and those being sponsored by an entrepreneur.

It has been significant that the collaboration between a top-tier engineering design program and one of the top entrepreneurship programs in the country has been able to engender teams that have produced excellent technical designs, outstanding business plans, and have been successful in the business plan competition.

This study has provided valuable information regarding the “efficiency” with which projects are implemented. Several trends have been identified which will be used as examples for future project teams and in communication with the sponsors. The projects analyzed here conform to those reported for industry projects.

References


