Technical Entrepreneurship as an Undergraduate Course

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Abstract
This paper describes the content, methods and student activities of an undergraduate course in technical entrepreneurship. The course engages students in a variety of research, problem solving and critical thinking activities as they seek solutions to practical problems faced by designers and engineers bringing products to market. The one semester course requires students to present product concepts to the class during the second week of the semester. Acting as a product development committee, the class weeds out weak products to identify those with greatest potential. Product engineering teams are then organized, to further develop the ideas, through the development of engineering drawings, production of a prototype, and cost and market studies. Having completed this work, the teams present their results to the class as students determine which single product to produce during the semester. Once a product is selected a company is formed, complete with shareholders, corporate charter and a management structure. The company’s objective is to develop a production system that will allow for the production of 101 complete and packaged products. The products are sold and the class dissolves the company. Students invest real dollars to become shareholders and dividends are distributed at the close of the company.

The course described goes beyond the cerebral aspects of entrepreneurship. Rather, students develop an actual organizational structure and real production system as they physically produce products for market. Students experience real-world problems as they embark on the exciting and often exhausting journey of bringing new products to market.

I. Introduction

The Department of Industry and Technology at Millersville University of Pennsylvania offers a baccalaureate degree in Industrial Technology with six areas of specialty: CAD/D, Electronics Technology, General Industrial Technology, Graphic Communications Technology, Manufacturing Technology and Mechanical Technology. All undergraduate Industrial Technology majors, regardless of specialty area, have an entrepreneurial experience via a required upper-level course. The course, Industrial Organization (ITEC 492), is offered at least once per semester and typically enrolls between 18 and 24 students. Meeting six hours per week, with approximately two hours lecture and four hours lab, the course explores the organization and operation of a small manufacturing enterprise. Students, typically seniors, put into practice the concepts and skills developed in business and technical courses as they work as a team to bring a product to market. As a goal, the class must produce a minimum of 101 products in about eight production hours.
II. The First Five Weeks

The development of a viable product is an activity that can be reduced to essential elements in order to aid the process. The first activity is to identify potential products. Each student is to bring an idea for presentation to the class. Since this is not a class that focuses on invention or innovation, the goal is simply to identify a suitable product, which could fall into the category of an adaptation or imitation of an existing product. The product ideas must be sketched and include a basic parts and materials list. As students present their ideas, classmates evaluate on a scale of 1-4 the product’s appeal, marketability, financial feasibility and potential to meet the production quota of 101 finished products. Depending upon class size, four to five of the product ideas with best potential are identified. This activity, which is referred to as product ideation, is generally completed in one or two class sessions and occurs during the second week of the semester.

With the list of potential products narrowed, student product engineering teams are formed. Each team is comprised of the person who contributed the idea along with three to four other students. Teams are balanced with students who have identified strengths in drafting, production processes and business concepts (this information was gathered during the first class session). The focus now is to engineer the ideas into marketable products.

Refinement is the first step in the process of product engineering. Teams gather and review the product sketch and parts/materials list. Discussion initially revolves around individual likes and dislikes according to personal taste, but quickly turns to a concerted effort of analyzing the idea in detail. Among the topics for review are part dimensions, material selection, hardware and fasteners, construction methods and cost saving. Products can be modified as needed to make them better or improve manufacturability, however, major changes that drastically alter the original idea are not allowed without consent of the class in total. Once refined, the teams embark on a number of tasks, delegated to individual members. These tasks include: creating working drawings, developing a detailed materials list, creating a working prototype, analyzing similar products on the market, developing a cost estimate along with profit projections and conducting a market survey of 100 people. Two to three weeks are allowed to complete this work.

During presentation of their product engineering work, the teams distribute packets summarizing the results. Class members listen to the presentations, discuss the information in the packets and ask questions. The objective is to identify which one of the four or five products has the greatest possibility for success. The task is not easy and debates are energetic resulting in lengthy, in-depth discussion regarding each product. Ultimately though, through a closed ballot vote, a single product is selected and a company structure is then formalized.

III. Forming a Company

Depending upon the size of class, different organizational structures are possible. All class companies elect a president from amongst the group. Students then apply for “management”
positions in one of four departments: production, finance, human resources and marketing. Typical company positions are identified below:

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<tr>
<th>Production Department</th>
<th>Marketing Department</th>
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<tr>
<td>Production Manager</td>
<td>Marketing strategist</td>
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<td>Quality Assurance Director</td>
<td>Advertising</td>
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<td>Production Planning and Control</td>
<td>Packaging</td>
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<td>Industrial Engineering</td>
<td>Sales</td>
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<th>Human Resources</th>
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<td>Employment</td>
<td>Finance Director</td>
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<td>Safety and Training</td>
<td>Comptroller</td>
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<tr>
<td>Wage and Salary Administration</td>
<td>Purchasing Director</td>
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Including the president and vice-president of each department, the organizational structure above would be for a class of twenty students. Other positions are possible to accommodate larger classes.

Using examples of past student work as well as library resources, students are required to research the position they are “hired” to perform and draft a contract of the activities of that position. This contract serves as a basis for evaluation in determining the extent to which they satisfied their job responsibilities. The contract also provides students with a roadmap that guides them through the job. Concurrent to this, students are developing what is termed a “company identity program” consisting of a legal name, product name, trademark and slogan. Each student is required to submit ideas for consideration and using the democratic process the selection of a company identity is made.

With a refined product, students in job positions, and a company identity selected, the next task is to formalize company ownership. Using resources available from the Commonwealth of Pennsylvania (http://www.dos.state.pa.us/corps/forms.htm), the finance department drafts articles of incorporation and company by-laws. (It should be noted that although the company is not a legal entity, the exercise of going through the incorporation process is a valuable learning experience). Each department meets to prepare a budget. A master budget is then prepared by the finance department and presented to the president for approval. Next a stock offering is drafted and students begin to invest in the company. It is not uncommon for a class to invest a total of five hundred or more dollars in the enterprise. Thus students have a “vested interest” in the company. While investing is not a requirement, most students do buy stock. Only the stockholder and the finance director know the amount of each student’s investment and that investment or lack there of in no way influences their grade in the class. Students are constantly

reminded that they are not required to purchase stock in the company.

IV. Department Work

Each student is a member of a department, an employee of the company, a stockholder, a production worker and of course a student in the class. To be sure, these multiple hats create problems, particularly when decision must be made that might have an effect on the other hat they are wearing. Regardless, each and everyone have specific responsibilities, which, in order for the company to succeed, must be met.

The Production Department is responsible for creating the system to produce the products. Manufacturing 101 products in eight hours, even those that are relatively simple, can be a mind opening experience. The scheduling, sequencing, identification of appropriate methods, tooling, and other tasks are a challenge for even the best student. No one ever seems adequately prepared for all that is involved in pulling off a successful production run and doubt and concern abound. The turning point in the production department work is the pilot run. After this, much of what consisted of merely plans on paper has come to life and the reality of it all is clear. With additional fine-tuning, success appears within reach.

Students in the Marketing Department must create the methods for getting the product to the consumer. The marketing strategist presents a proposal for marketing the product. Although products are mostly sold on campus, the presentation is important. Data from the market surveys, conducted during the product-engineering phase are once again employed. The advertising director, packaging director and sales manager all use market strategy information in their work. Students learn first hand the high dollar cost of advertising and packaging as they prepare ad copy and design an appropriate container for the product.

The Finance Department is an area most students shy away from, usually due to lack of understanding. Those involved in this department quickly learn the necessity of keeping accurate financial records and reporting. The purchasing director has the job of securing materials at the “right price, quality, quantity and time”. Problems acquiring materials has frequently been the bane of class companies. The finance director, working with the marketing strategist, develops a breakeven analysis to help determine the appropriate price-point. Having opened a checking account at a local bank, the comptroller pays company bills and prepares financial statements for presentation to the stockholders.

Students in the Human Resources department interact primarily with the production department to supply a workforce for the production run. Student workers are paid a small hourly wage based upon the job assigned and punch-in for work on a timeclock. Establishing a wage policy is therefore another department duty. Additionally, developing and enforcing safety policies as well as ensuring a trained workforce are also department requirements. The safety director establishes lock-out/tag-out procedures, safety dress requirements, inspects processes and develops a safety manual for the company. Material Safety Data Sheets, Right-to-Know
information and other OSHA related information must be researched and used accordingly by the company.

The executive committee (the company president and department vice-presidents) meet each class session to plan strategy, form policy, examine the budget, compare department reports with goals and schedules and attend to the many crises that develop. The professor attends executive committee meetings as an observer. If questions are brought to the professor’s attention, they are attended to, however, every effort is made to let students solve their own problems. Unless the class is clearly “off-the-mark” with no obvious hope for solution, the professor steers clear of helping out.

V. Manufacturing Products

While the goal is 101 complete packaged products in eight hours, not all groups are successful and for reasons of economy some choose to exceed the goal. Production occurs during the regular class meeting time and if necessary over other extended periods of time such as a weekend day or evening. If the class exceeds eight hours, and time allows, production may continue with the penalty of time-and-a-half wages for employees. All students participate in the production run as workers, regardless of management position. Possible exceptions to this are the managers of production, safety and quality assurance, who may remain in management capacities during production if demanded by their contract.

Having applied for production jobs, hired, trained and indoctrinated, students report for “work” according to the production schedule. Doing what can be a monotonous, dusty, noisy, sweaty job for several hours at a time is an awakening experience for many. The earlier stress of planning for the production run has now shifted into worker stress and sometimes dissatisfaction. As production problems arise, and they always do, students frequently become irritable and the tension is thick. Trying to remain focused and solve problems under extreme pressure is a challenge and itself an important life lesson learned quickly in this class.

All students make a contribution to the production system in the form of tooling design and fabrication. As a course requirement, everyone must design and fabricate a jig or fixture according to the needs identified by the production department. Tooling needs are posted in the classroom along with a detailed description of function. Students submit a tooling design for approval by the company’s manufacturing engineer. Once approval is granted, the designer then fabricates the tooling, which undergoes final testing prior to the pilot run. During the actual production run, the professor evaluates student’s tooling as well as the company’s production system (process selection, plant layout, material flow, etc.).

It is always gratifying to see the look of pride and amazement in the faces of students as the first products come off the line. What began an idea in the mind of a single student and then
engineered by a small team has come together through the work of an entire class, as product ready for packaging and sales.

VI. Closing the Company

Sales locations are set-up on campus where only complete, packaged goods may be sold. Any product not sold must be liquidated, along with other company assets such as parts, defective goods, unused materials, etc, as the business winds down. Liquidation auctions have been known to bring significant revenue to a company during its final hours of business.

In order to bring closure, workers and invoices must be paid, stocks redeemed and dividends distributed. The finance department prepares a final financial statement, which along with the Articles of Dissolution are included in an annual report to the stockholders. Rarely has a class lost money and in fact, in over fifteen years, only two classes closed in the red. It is not unusual for a company to post a 50-75% net profit.

VII. Final Thoughts

The experience of bringing a product to market leaves a lasting impression on students and my result in their taking the leap to entrepreneurship. While I do not track the progress of alumni, I have learned of student attempts at bringing products to market. One such example I learned about quite by accident.

At the end of the semester, several years ago, a student requested to keep molds used during the production of a class product. The product, a backlit bar style sign, with the university logo and clock on the front, was a popular item. I didn’t ask the student about his plans and eventually forgot about his retaining the molds. Some time later, I was strolling past a local retail shop that specialized in college supplies and memorabilia, glancing at the window I stopped abruptly. There, brightly lit and prominently displayed was a bar style sign strikingly similar to the one produced by my class. Upon inquiry, I learned that a small company was producing these products, made available with different college logos, and distributing them to college stores throughout the state. The student from my class, as it turned out, used the molds to start a small business. He managed to improve on the screen-printing of the logo and clock face, but all other aspects seemed the same. Needless to say, I felt a great deal of pride and admiration for the student.

Graduates of our program often cite the Industrial Organization course as one of the most beneficial in their undergraduate curriculum. The problems faced in class mirror those in the “real world”, but are dealt with in a relatively safe environment to allow for optimum growth and learning.

It is essential for students experience problem solving, teamwork, cooperation, leadership, followership and personnel issues in order to be successful technology managers. Typical college courses do not include such experiences. Additionally, the processes involved in developing a product and creating a complete system to bring it to market is an entrepreneurial experience from which a multitude of learning tasks place. The ramifications of this course include the immediate satisfaction of accomplishment as well as the long-term knowledge that can be applied for years to come as students reflect on their experience and lessons learned. I can think of no better way for students to learn first-hand about technical entrepreneurship than through a class such as the one described above.

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Barry G. David is an Associate Professor in the Department of Industry & Technology at Millersville University of Pennsylvania where he has taught since 1983. Specializing in production processes and technical entrepreneurship, Dr. David has served as curriculum developer and consultant to both education and industry. He has recently contributed to the Society of Manufacturing Engineers’ Tool and Manufacturing Engineer’s Handbook Volume 8, and has presented on the topic of technical entrepreneurship at both regional and national conferences.