AC 2010-952: BUILDING THE ENTREPRENEURIAL MINDSET IN SENIOR PROJECTS

Kenneth Cook, Lawrence Tech University

Ken Cook is the chair of the Department of Engineering Technology in the College of Engineering. Mr. Cook is a registered professional engineer, a certified clinical engineer, and holds some 28 patents of his own. He holds degrees from or attended DeVry Technical Institute, Lawrence Technological University, Wayne State University, and Oakland University. Cook has many years of experience in engineering management and sales. His was most recently executive vice president and chief engineer for Vultron/Trans Industries. His earlier positions included General Manager of R&D in machine tool controls and gauging at GTE-Valenite Corp., started and managed the clinical engineering department at William Beaumont Hospital, Royal Oak, and was a research associate in radiology, nuclear medicine, and bio-mechanics at Wayne State University. Ken has taught at Lawrence Tech evening programs as an adjunct instructor since 1965. His senior projects class, where students generate project ideas, research, design, manufacture, and assess the market for inventive products is the capstone course. Cook also has enjoyed a long side career in magic finding his hobby very useful in teaching. A highlight for his students each year is the two-hour magic performance he offers as a congratulatory send-off for them and their guests.

Jerry Cuper, Lawrence Tech University

Jerry Cuper is a professor and advisor in the Department of Engineering Technology in the College of Engineering. His education includes graduate and undergraduate degrees, and completion of a technology apprenticeship program. Mr. Cuper's career has spanned a wealth of experience in the machine shop, on the drawing board, in construction, and many years in engineering design, testing and development, management, and planning. Most of his career was with the Ford Motor Company. Mr. Cuper's last assignment was managing the Ford Technology Review Center to help implement suppliers' new technologies. He developed and led the implementation of a new supplier process to dramatically change the way supplier technologies were integrated into Ford products. This supported Ford's vision to change from being a fast follower to being a leader in technology. Mr. Cuper developed the first-production automotive application of Graphite Fiber Reinforced Plastic; this bracket was given the Materials Engineering "Award of Merit". Cuper has taught courses in engineering and business at Lawrence Tech evening programs as an adjunct instructor since 1978. He has demonstrated the ability to work extremely well with students to focus their efforts on academic achievement and long-term career goals. Mr. Cuper's passion is muscle cars. He has owned 20 Mustangs over the years, starting with the 1965 2+2 Fastback and now has a 2010 GT convertible.

BUILDING THE ENTREPRENEURIAL MINDSET IN SENIOR PROJECTS

Abstract

Imagine the challenge of teaching a capstone course that sparks the entrepreneurial mindset in students. Building this mindset required several teaching techniques that were used for years and have proven successful in establishing the framework for this attitude. This course is comprised of students from different academic majors working on the same project. The student majors cover the spectrum of electronic, mechanical, construction, industrial, management, architecture, and manufacturing technologies. These different majors prove to be a great asset for the project teams. Just as in industry, a varied group of people with diverse backgrounds are pulled together to successfully complete a project. Students are expected to conceive an idea, research, develop, manufacture, market, and establish a sales distribution network for their product. This duplicates real-world pressures to produce a quality product with market viability in a short-delivery time. The professor acts as the CEO of an international corporation and the students are employees from different operating divisions that are in trouble. They are brought together to develop new or innovative products. It is very important in the entrepreneurial mindset that a management style be established by the CEO/professor that fosters teamwork with a free spirit of brainstorming new products. This structure provides real-world situations as in industry. Students must demonstrate their product to the CEO/professor, their peers, and industrial advisors.

Foundation for Entrepreneurial Spirit

Lawrence Technological University (LTU) was founded in 1932, as a result from Henry Ford and the educational community requesting part-time programs in the evening. At that time, there were no colleges or universities in the Detroit area that offered evening courses. The Dean of Engineering at the University of Detroit (U of D), Russell Lawrence, was approached to create a night school program. He left U of D and started Lawrence Institute of Technology (LIT) to offer engineering and technology programs that were open to part-time as well as full-time students. Mr. Lawrence had the entrepreneurial spirit to start LIT even in the depressed economy of 1932.

In1986 the Bachelor of Science in Technology degree was initiated and the name was changed to the Bachelor of Science in Engineering Technology in 1990. As a foundation for this program, and since the LTU philosophy is "Theory and Practice", a capstone course needed to be developed. An important requirement for this senior project course was to have it taught by a professor that had an entrepreneurial mindset. Also, the senior project would use all of the skills that students learned from their previous courses.

In 1989 Lawrence Institute of Technology became Lawrence Technological University. During that change, the School of Associate Studies became the Engineering Technology Department within the College of Engineering. The Engineering Technology department has a rich heritage within Lawrence Tech over the last 70 years.

The Entrepreneurial Mindset Definition

Today, more than ever before, it is paramount that educators embed creative and entrepreneurial thinking into course content. Often we ask – What is the entrepreneurial mindset? There are many definitions of the entrepreneurial mindset. The author of The Entrepreneurial Engineer, David E. Goldberg, states that ". . . today's engineers . . . requires a more venturesome attitude and approach. Increased competition places enormous pressure on companies to continue to improve and innovate in creating new product lines, acquiring new customers, adopting new technology and implementing better business practices." [1] The Entrepreneurial Mindset is best defined by Donald Kuratko in his book "Entrepreneurship: Theory, Process and Practice. He states the Entrepreneurial Mindset is when an individual exhibits the behavior of an entrepreneur, where this behavior consists of some of the following characteristics: opportunity and goal orientation, taking initiative and personal responsibility, persistent problem solving, realism and a sense of humor, internal focus of control, and risking taking. [2]

The Senior Project – Entrepreneurial Learning Experience

This capstone course was developed to spark the entrepreneurial mindset in students. The learning experience is designed to bring together the experiences, in and out of the classroom, that have been part of the educational journey taken by all college students. However, this course has been created to be different in its approach to the capstone experience, by the authors' real-world entrepreneurial experience which has been integrated into this.

The approach utilized in this senior project course is innovative in engineering education. It combines methods used in business and engineering to create products in an environment that is representative of today's industry.

The learning outcomes and expected performance criteria for the course is: 1) Participate in a product development cycle from brainstorming to a deliverable product, 2) Conduct a patent search, market survey, and production analysis hitting a target 15% return on investment (ROI), 3) Experience an entrepreneurial mindset process necessary to start a business, and 4) Present a final product presentation to the advisory board by the team. This is video documented.

An experienced entrepreneur developed and teaches this capstone course because of his many years of experience in engineering, management, marketing, sales, and entrepreneurial thinking. He is a corporate entrepreneur with 30 patents in many industry areas from medicine to machine tools to electronic display systems. Based on this experience and know-how, the professor is well

prepared to foster an awareness and understanding of intellectual property and entrepreneurial mindset.

The senior project course is comprised of students from different academic majors working on the same project. Just as in industry, a varied group of people with diverse backgrounds work together to successfully complete a project. This is similar to the approach conducted at Stanford University in multidisciplinary teaching and research.[3] Student majors cover the spectrum of electronic, mechanical, construction, industrial, and manufacturing technologies, as well as management, and architecture. These students prove to be a great asset to the Entrepreneurial Teams (E-Teams). These teams have developed products over the years for markets including sporting goods, disability aids, cooking, toys, baby, pet, transportation, communications, navigation, display systems, manufacturing systems, construction, lighting, embedded controllers, etc.

The professor starts the class and says he has to leave the classroom and a CEO will conduct the senior project course. The professor returns and act as the CEO of an international corporation and the students are employees from different operating divisions that have technical or business issues. They are brought together to develop new or innovative products to make their divisions sustainable and profitable. It is very important to establish the entrepreneurial mindset by the CEO/professor (CEO/P) that fosters teamwork with a free spirit of brainstorming. This structure provides real-world situations as in industry. The CEO/P acts as a mentor who provides encouragement and instills confidence that the employees/students (E/S) can deliver the product on time while meeting the project objectives.[4]

Brainstorming

The E/S brainstorm as a group over several meetings and their ideas are recorded. To help develop creativity, the CEO/P uses several methods such as asking E/S to think about ideas using experiences, hobbies, family interactions, work experiences (not specific to their employer), to think about putting things together that you wouldn't necessarily put together to see what happens, and to think about situations that presented issues when trying to do something. The CEO/P introduces humor and some prestidigitation in the brainstorming session and throughout the class work. This helps to relieve stress and facilitate the flow of creative juices.[5]

Creating Entrepreneurial Teams

The product ideas are scrutinized by the CEO/P to eliminate ones that could not be completed in the allocated time frame, are outside of the scope of technical feasibility, or requires resources beyond their financial means. The E/S is asked to review these product ideas and to use their "heart and head" to vote their first and second choice. This voting selection does not have to include their E/S own product ideas. The voting is open and verbal with the entire E/S involved in the process, and is completed in a short period of time.

It is important to note that the formation of the E-Teams is based on the selection of the product. Over the last 25 years, the CEO/P has found that each E-Team should have 2 to 4 members, with 3 being optimum. The E-Teams are formed by first or second choice voting preferences. Teams of less than 3 make it more difficult for the members to complete all of the necessary tasks. Teams of 4 or more do not appear to work effectively; 2 or 3 of the members tend to do most, if not all of the work, while the other members are trying to determine where they can be helpful.

To determine the strengths and academic specialties of the E-Team, the members interview each other. The outcome of this determines their position/title in the organization chart of their operating division under CEO/P Enterprises. Examples of this could be vice president of engineering, manufacturing, and marketing. The E-Team establishes a divisional name, logo, mission and quality statements, and preliminary product abstract. The next step is to develop a project timeline or Gantt Chart, using Microsoft Project ^{TM} from a list of tasks required to complete the product.

Intellectual Property Search

A lecture is given on all forms of Intellectual Property (IP) and specifically utility patents. Using this information, a preliminary IP patent search is performed using the United States Patent and Trademark Office (USPTO) website.[6] Based on information obtained from this search, the product idea may be improved, modified, or abandoned. A patent attorney guest lecturer reinforces their experiences and findings after their IP patent search.

Market Survey

The product abstract, used for the market survey, could be edited using the patent search information. The market research questionnaire, based on previous experience, should be no more than 10 multiple-choice questions. This survey should consist of questions pertaining to the demographics of potential customers, selection of product features and price points associated with it. Also, the questions should ask if the customer will buy this product, and if so how much are they willing to pay for it. Analysis is performed on the data consisting of numerical and graphical presentation. The information from this analysis will be used for product features, manufacturing requirements and advertising penetration.

Product Specifications, Design, Testing, Production Requirements, Advertising Plan

Product specifications should be based on requirements learned from the IP patent search and the market survey. The design, engineering/CAD drawings, prototyping, bread boarding, and preliminary testing should be completed to meet the basic product specifications. If this is not met, then a redesign may be required.

If the preliminary design is proven functional, then final material procurement, construction, packaging, and testing should be finished. Next, product documentation, bill of material, cost and break even analysis, should be completed.

Production requirements and inventory turnover are determined by the results from market size and customer survey. If the target ROI is not met, several techniques should be employed, such as increasing advertising for improved market penetration, improving manufacturing efficiency (off shore versus local), and improving product features or application.

Final Presentation and Product Demonstration

Several oral presentations and work outside of the classroom are required from the E-teams throughout the course.

A video documentation is done of the final presentation and product demonstration by each E-Team. The E/S must prove and demonstrate their product to the CEO/professor, their peers, and the Engineering Technology Industrial Advisory Board. A project book is assembled during the total development cycle and contains all documentation in printed and electronic format. The team project book, which will be submitted at the end of the term, contains the following:

1. Division name, logo or trade mark etc.
2. Table of organization with each member's title and responsibilities.
3. Autobiography of each member of the team.
4. Brainstorming notes, sketches, product ideas, etc.
5. Product/project timing using MS Project ^{TM}
6. Mission statement
7. Quality statement
8. Product name and logo including a description or abstract.
9. Patent search, class, sub classes, and copies of previous art work, discussion of IP patent search outcomes.
10. Market research of the product. This includes the survey questionnaire, customer survey results, product trade-off analysis, measurements and conclusions.
11. Product engineering includes design, CAD drawings, calculations, testing, data analysis, software, sustainability analysis, packaging, recyclability, bill of materials and parts cost.
12. Manufacturing includes cost, quantity, quality control measures, in-house, farm-out etc.
13. Financial includes break-even-analysis, inventory turns, and a 15% ROI within a five-year start up.
14. Marketing, sales distribution, advertising
15. Product manuals etc.
16. Miscellaneous

Entrepreneurial Application Center – a solution place

Lawrence Tech created a facility with a grant from the Kern Family Foundation (see Appendix). It is being used by students who are members of entrepreneurial teams (E-Teams). The center

provides work areas for development of student projects from the initial idea to possible commercialization.

The center, consisting of 3000 sq ft., comprises of distinct dedicated areas for individual work spaces, team meeting rooms for brainstorming sessions, conference room for presentations, rapid and prototype areas, bench fabrication, project and supply storage. It is located in the Applied Research Center (ARC).

Team Room: Teams use an office environment and conference rooms that allow for individual work and group brainstorming sessions.

Fabrication Lab: The existing Fabrication Lab provides a prototype machining area with additional tools that include: Metal forming machines, a shear, finger break, and a notching tool, a gas metal arc welder, layout and measuring instruments, and misc. tools.

Rapid Prototyping: The facility includes a dedicated computer, an E size plotter, and a rapid prototyping 3D printer.

Student Work Area: Students have work spaces and benches for fabrication of their projects, and a secure area to store projects and work in progress. An existing fenced area will be expanded and additional workbenches will be installed.

Team and Advisory Board Assessment

Four to six oral team presentations are required, with CEO/P, peer grading, and team member feedback. The last presentation is witnessed by the advisory board with their live comments and is video recorded. A team thesis/business plan is required to be submitted to the CEO/P and retained by the Engineering Technology Department. Also, all projects are photo documented.

Relationship of Course to Program Outcomes - *meets the intent of ABET a-k Outcomes* (see Appendix)

Framework for E-Team Success

Successful product development by E-Teams can be summarized as follows:

1. Team Ownership – take product ownership and make commitment to complete
2. Understand the Customer/Market – who is the customer?
3. Team Communication -- all for one, and one for all
4. Apply Critical Thinking – apply engineering and science to solve problems
5. Meet Delivery Date – know delivery date and indicate steps required to meet this date

Lessons Learned

Improvements learned from over 25 years of experience with senior project E-Teams are as follows:

1. Introduced guest lecturers -- patent attorney, marketing professional, and financial advisor
2. Improved the brainstorming and voting process for project selection by shortening the project selection time and increasing the allotted time for brainstorming
3. Added video recording to document the products
4. Involved Industrial Advisory Board in the final product presentation and demonstration
5. Made the Intellectual Property search more extensive with the use of internet access
6. Targeted specific users/customers in the market research

Bibliographic Information

1. David E. Goldberg, The Entrepreneurial Engineer, 2006: 1, 2.

2. Donald F. Kuratko and Richard M. Hodgetts, *Entrepreneurship*, 2007: 5, 118.

3. Stanford University website: http://multi.stanford.edu/, January 4, 2010

4. John C. Maxwell and Jim Dornan, *Becoming a Person of Influence*, 1984: 66-70.

5. Donald F. Kuratko and Richard M. Hodgetts, *Entrepreneurship*, 2007:150-151.

6. United States Patent and Trademark Office website: http://www.uspto.gov/, January 4, 2010.

Appendix

Kerns Entrepreneurial Education Network (KEEN) Grant

Lawrence Tech is one of 20 schools participating in the Kerns Entrepreneurial Education Network (KEEN). The Kern Family Foundation of Waukesha, Wisconsin has funded the KEEN schools to foster the entrepreneurial mindset within the engineering environment. LTU is the recipient of a grant from the Kern Family Foundation, which included the creation of an Entrepreneurial Application Center.

Relationship of Course to Program Outcomes - *meets the intent of ABET a-k Outcomes*

Outcome	Support Rating	Rationale for Rating
a	3	Student will use knowledge, techniques, skills, and modern tools learned in their previous courses.

b	3	Students will apply current knowledge and applications of mathematics, science, engineering, and technology for their projects.
c	2	Conduct, analyze and interpret marketing and test data, and apply results to improve their designed product.
d	3	Apply creativity in the design of systems, components, or processes appropriate to their product.
e	3	An ability to function effectively in teams necessary to make delivery of the project on time.
f	3	The ability to identify, analyze and solve technical problems by themselves or with external help necessary to complete the product.
g	3	Communicate effectively with 4 to 6 oral presentations, with peer and advisory board review.
h	2	Many students recognize of the need for an engagement in lifelong learning when they have to push the technical envelope during the product development phase of their product.
i	2	Understanding their product could impact the professional, ethical and social responsibilities.
j	2	Diversity and contemporary professional, societal and global issues are evident because student teams consist of a mix of men and women, with different ethic cultures working together on team projects.
k	3	The team mission and quality statements emphasize quality, timeliness, and continuous improvement

Key to ratings: 3 strong emphasis, 2 emphasis, 1 minor emphasis, 0 no emphasis

Student Testimonials

Shown below is a sample of student comments about their experiences in the Senior Project course relative to the E-Team multidisciplinary academic majors and the Intellectual Patent search process:

"The different student majors helped to draw on each other's strengths and personal traits. The patent search helped our group to analyze the design in more depth. This helped to change our technology direction and solved some problems."

Keith Kochan, Architecture & Construction Management, Senior

"Having different student academic majors helped to separate the responsibilities for the different tasks required. For example, one of the students was mechanical, one was in manufacturing, and one was electrical. These different talents helped to design and package our product. The patent search caused new ideas for the original design"

Riki-Lee LaChance, BSET '06, mechanical

"We had one student who was in electrical, one in manufacturing, and one who was working in a family-owned business. The make-up of our team really helped to design and develop a market plan for our product."

Debra Hodges, BSET '06, mechanical

"The team worked extremely well together, especially using their different talents to help with the design and market research. After doing the patent search, we realized that we could expand the applications of our product."

Steven Charles, BSET, manufacturing, Senior