2006-2103: THE MS-MBA DUAL DEGREE PROGRAM: AN INTEGRATED ENGINEERING AND BUSINESS APPROACH TO PRODUCT DEVELOPMENT

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The Combined MS-MBA Program: An Integrated Engineering and Business Approach to Product Development

Abstract – The University of Tennessee at Knoxville initiated the innovative dual degree program in the fall of 2001. Its focus is to integrate the skills and knowledge of students studying both engineering and business, and to direct those skills to product development. It permits students, in 23 months, to obtain a Master of Business Administration [MBA] degree and a Master of Science [MS] degree in an engineering discipline. It is expected that, by the completion of the program, student teams will have developed a concept, a business plan, a marketing plan and a prototype for a marketable product. The vision of the MS-MBA dual degree is not merely to allow students to receive two graduate degrees in a compressed time frame, but to tightly integrate the two degrees, so that multidisciplinary student teams develop an industrial product from concept-to-market.

Keywords: MS-MBA, dual degree, multidisciplinary, product development, entrepreneurship.

BACKGROUND

The combined MS-MBA program at the University of Tennessee [UT] is unique in its focus on product development and entrepreneurship. Students not only learn theory, but also actually develop, build and market a real product by incorporating technological challenges from the engineering side; and accounting, law, and logistic challenges on the business side.

Program Overview and Goals

Upon graduation from the UT program, students shall receive an MS degree with a major in a selected engineering discipline and an MBA degree. In general, engineering students work on multidisciplinary teams toward the development of a specific product. During the first year of the program, core MBA courses are taken and numerous product ideas are evaluated by the team partners. One particular product is selected for development based on technology and market considerations. In the second year, actual prototypes are developed and tested, business and marketing plans are researched and established, and products are made ready for full-scale production and commercialization.

The ultimate goal of the UT program is to develop engineering students that have the right combination of technical and business-marketing skills to effectively create and work in technology-driven businesses. Students involved in this program will have the ability to initiate small, technology-based companies [entrepreneurship] or innovate new products within an existing company [intrapreneurship]. The students will gain valuable experience and confidence in working in multidisciplinary teams with the overriding goal of developing a technology from concept-to-marketplace.

Real World Experience
The MS-MBA program at UT is viewed as a practice-oriented graduate program that fosters entrepreneurship and new product creation. It is designed for students with an undergraduate degree in engineering who wish to broaden their design and analysis skills with new computer-based productivity tools. The program also assists students in learning business functions essential to new product development in an industrial setting. Graduates of this program will be well prepared to pursue various career paths outside of academia, but in particular, their career progression may proceed in the technical and/or business direction with an emphasis on entrepreneurship for small start-up firms or intrapreneurship for existing, well-established companies.

By working in a team environment and solving realistic industrial-relevant problems, the students will be engaged in a first class educational experience dedicated to product development. It is this real world experience that is probably the most important attribute of the combined MS-MBA curriculum, as it teaches the students how to succeed in life and prepares them for lucrative careers in the technological-business arena. Some of the key qualities for success in the program include: making good judgment, taking the initiative, being a self-starter, having good work habits, having a good attitude, being able to work effectively with people in a group environment, and developing sound technical, economic, and communication skills.

Curriculum Highlights
The combined MS-MBA degree program consists of 60 total credit hours over a 23 month period on the UT campus. The curriculum split is defined to be 44 hours (17 months for a full-time MBA student) in the College of Business Administration and 30 hours in the College of Engineering (12-18 months for a full-time MS student). There are 14 credit hours of actual overlap between the two colleges, and this credit represents the time associated with the practical, product development curriculum study. This overlap compresses the time to complete the degrees.

A dual degree program, with an emphasis in manufacturing, was initiated at the University of Tennessee, Knoxville in 1997. The program described here, with an emphasis on product development, began in 2001, with the first graduates completing the program in 2003. In 2001, the combined program was only focused on majors in the industrial and mechanical engineering departments. Beginning in 2005, the MS-MBA program has expanded to be college-wide.

Within the business school, the 30 hours of business classes are focused on general management and integrated value chain topics. Some of the management classes include accounting, finance, economics, statistics, business law, and global business. Dual degree students also complete courses in innovation and entrepreneurship.

In general, the engineering and business schools place a strong emphasis on personal and leadership development throughout the 23-month curriculum. After completing the rigorous MS-MBA program, students will have the capability to integrate both technical and business knowledge in their career pursuits, understand how to construct a business plan and present ideas to investors, work in teams to move from idea generation to commercialization of a new product,

utilize an entrepreneurial skill base and mindset, and understand theory while also being able to bridge analytical and computational knowledge into practical industrial applications.

NEW PRODUCT IMPLEMENTATION

To experience the reality of birthing a new product and bringing it to the marketplace, the MS-MBA program exposes students to various practical strategies to facilitate the product implementation process: product selection and evaluation criteria, industrial collaboration, design and testing philosophy, and lessons-learned from past projects.

Product Selection and Evaluation

This phase of the combined MS-MBA curriculum is initiated in the fall semester of the first year of the program, and is continued throughout the spring term. The goal is to practice design by working on industrial problems having realistic restraints, where students receive the benefit and opportunity of learning from practicing engineers.

This three-credit hour course (one-credit for the fall term and two-credits in the spring) is focused on the identification, selection and evaluation of new products. The class is divided into teams of two or three people, and each team will identify one unique product that will be the group's concentrated effort for the next 18 months. Descriptions of potential products are given to the students in the beginning of the fall semester. These product ideas are generated by the industry partners (described below under "Entrepreneurial Board") and by engineering professors within UT. Also, students are encouraged to present their own concepts for review and evaluation purposes. As a part of a new grant from the National Science Foundation, an "Idea Bank" is being developed which will contain ideas from these multiple sources, as well as any maturity that has been added to these ideas from past teams.

By way of guidance and instructional support from the professors and industrial partners, each student team must perform an engineering assessment on the product's feasibility to meet certain performance constraints and development requirements. This assessment includes issues such as risk of development and prototype costs, as well as production and tooling cost estimates and related manufacturing concerns. Then, using their MBA-hats, the products are also evaluated for business and marketing feasibility. The eventual outcome of this process is for students to identify, evaluate, and select products that have the potential of becoming the beginning of a fruitful business venture and a successful commercial product – where the market "pull" meets the technology "push." A course in technology entrepreneurship is also being added to the curriculum (beginning in Fall 2006). This will introduce students to entrepreneurial issues, particularly those associated with technological products, and will also have several lectures dedicated to legal issues (choice of entity, intellectual property, and liability) taught by faculty from the College of Law and practicing intellectual property lawyers.

Design and Testing

This phase of product implementation occurs after the team has agreed to move forward on a particular product idea. The main steps in this process include: literature review, design sketches, CAD drawings, and prototype development and testing.

The literature review relates to examining similar or existing products that may have served the same function or purpose as the chosen product idea. At this stage, various key features are examined such as materials used, form and fit, aesthetics, product performance and price. Next, the team begins to develop some rough design sketches to attempt to put their ideas on paper, which facilitates the basic shape and design of the product and the placement of key features. These sketches are then transformed into CAD drawings, which place exact dimensions on the parts to better evaluate manufacturability and generate a bill of materials. The CAD drawings are also used to conduct a preliminary design review for the purpose of selecting the most promising design for prototype development. Various prototypes may be developed and tested until the team is satisfied with the product's features and performance measures. Lastly, a final design review is conducted before proceeding to a manufacturing and marketing plan. Note that the design reviews are done in conjunction with the student team partners, faculty advisors, and other interested entrepreneurial board members.

Once the final design is selected, the team details the manufacturing, packaging and assembly, and shipping requirements to arrive at a realistic selling price for the new product. The last step in the process consists of developing a marketing and business plan to facilitate the potential start-up of a successful company venture.

Entrepreneurial Board

The dual degree program involves the cooperation of 20 public and private partners, including Oak Ridge National Laboratory (ORNL), large corporations, small start-up corporations, and state and local officials. All aspects of the product development process are represented by the partner personnel – entrepreneurs, engineering, project managers, CEO's, intellectual property lawyers, state economic development officials, and venture capital representatives. These partners are involved in the following activities:

1) evaluating the dual degree program as a whole;
2) evaluating student projects and advising the student teams;
3) offering student teams technical and business expertise;
4) advising dual degree program in development and curricular issues;
5) contributing intellectual property (ORNL alone has a portfolio of over 1000 patents) and project ideas;
6) serving as guest lecturers in graduate product development courses;

Advising student teams involves attending student product presentations twice a year and asking "hard questions" about the product, both on its technological feasibility and its market possibility.

Lessons-Learned

One of the more difficult aspects of the combined MS-MBA program is finding and evaluating suitable engineering projects for product development. Since this phase is a critical component of the program, it is imperative that good product ideas are chosen upfront. And as discussed above, the process is initiated in the first year with a three-hour course on "Product Selection and Evaluation." The following items are some of the key lessons-learned and general comments regarding this important process.

- It is important that students are encouraged to contribute as many product ideas as possible. Experience has shown that students at this early stage of the program are fairly naïve as to what constitutes a possible and good product idea.
- It is important that the instructors give students a "roadmap" and instructions on how to properly evaluate potential projects. In order to complete a project in an 18-month period, all projects must have a certain level of difficulty, required resources, available technology and necessary information to achieve success.
- In the selection process, students are very anxious and capable of using the Internet to search for information and ideas. However, they are much less anxious to make personal visits. It appears that the Internet has taken the place of "shoe leather," and it is deemed very important to have a personal exchange of information with the opportunity for questions and answers, and the initiation of the learning process.
- In choosing a project, it is not important that the project necessarily originate with a student or student team. But it is absolutely important that the students' have a passion for, and believe in, the potential worth of the project. If the students do not have passion concerning the project, the product development process and the creation of a business plan just become another academic exercise.
- The instructor should not assign student teams. Experience has shown that the makeup of the teams will be formed during the period of time in which the projects are being evaluated.
- It is not necessary for all student teams to believe that they will start-up a new company as the result of their work in this program.
- It is important that the students present their work for review to an outside group of interested experts. Students will often accept comments and criticism with more authority from people outside the university than from professors.
- It is important to require that the student teams have a written agreement that details the legal rights and obligations of each team member upon graduation. This has been a very difficult task to accomplish, and students are very reluctant to provide closure in this respect.

SUCCESSFUL PRODUCT DEMONSTRATIONS

Although the dual degree MS-MBA program was only initiated in the Fall of 2001 at UT, some very successful product demonstrations have already been realized by its graduates. The projects that will be highlighted in this section include: the SAFELight device (from the first graduating class), and two other interesting projects that have been completed by student teams; namely the Lighted Dental Mirror and the Automotive Magic-Rim Lights.

The SAFELight Project

The SAFELight product was invented, patented, and marketed by a product development team from the 2003 graduates: Ben Jordan, Tony Spezia, and Nate Davis. The three inventors, through a new company called C2Innovations, are now marketing the SAFELight system: a braking light mechanism that provides an early warning signal for drivers in the event of abrupt stops or extreme braking maneuvers. As shown in Figure 1, the device uses standard OEM light

bulb components with the addition of control circuitry and an accelerometer to detect when the driver applies the brakes during a hard stop.

The above three graduates also received the Collegiate Entrepreneurs' Organization Award for outstanding innovation in May, 2003, and were finalists in the 2003 Collegiate Inventors' Competition. A patent has been issued for technology developed for the product, two of the students have formed a company, and have begun selling the product. The vision of taking a product from "concept to commercialization" has been realized in this case.

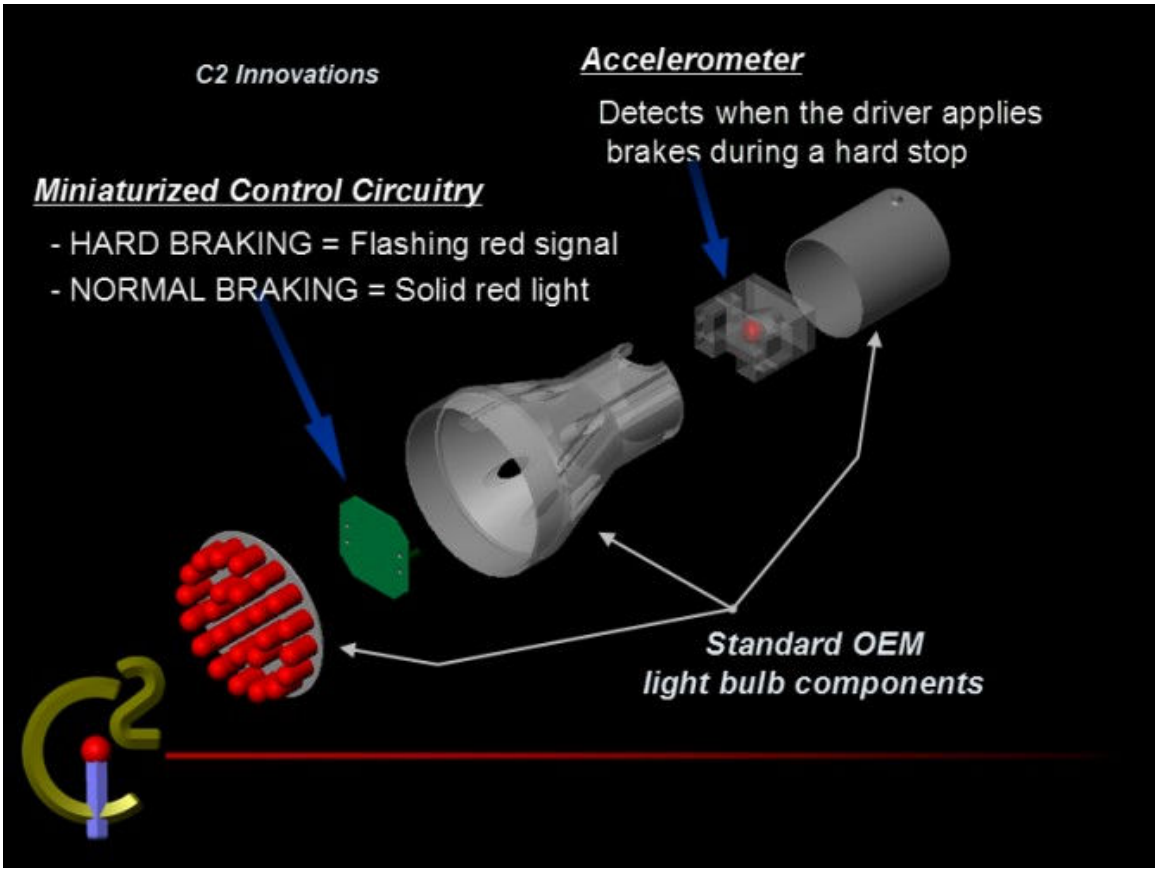

Figure 1. SAFELight Schematic

Lighted Dental Mirror

The dental mirror project was completed in the summer of 2004 by graduating students Eric Gunter, Mazi Arzanpouli, and Patrick Poling. This product team focused on developing an improved lighted dental mirror based on its market potential and simple design (see Figure 2). After an evaluation of existing dental mirrors, with input from two practicing dentists, the team identified the following key features for a lighted dental mirror: diameter of the handle, brightness of the light, aesthetics, and resemblance to a standard mouth mirror. The team then proceeded to design, test, and evaluate various prototypes. It was the development of the third prototype, as shown in Figure 2, that met their requirements. Various factors were considered in

the design process, such as the price of the components, battery size and type, light source and intensity, and the size of the dental mirror. The third prototype was selected as the final design and consisted of all stainless steel parts, a five millimeter LED light source, three 1.5 volt button-style batteries, a number 5 standard dental mirror, and a reduced diameter mirror-handle for ease of operation.

The development team also conducted a manufacturing, packaging and assembly, and a marketing analysis for this product, which translated into a unit production cost and a reasonable selling price for a competitive profit margin. In general, the lighted dental mirror should be able to compete fairly well in the dental industry supply sector.

Figure 2. Lighted Dental Mirror (third prototype design)

Automotive Magic-Rim Lights

The student team for this project consisted of Rick Kuhlman and Garrett Walker Tinkle. These two students recently graduated from the program in August of 2004. The motivation for the idea came from the fact that in a multi-billion dollar aftermarket car accessory business, over half of the sales were dedicated to appearance-related products. The product concept for this team was a set of replacement "magic-rim" automotive wheels or attachments that would have a series of LED lights extending from the center of the wheel rim and culminating at the rim-tire interface. The lights were to be controlled electronically so that the spinning wheel would create a persistent image for ease of visibility by other vehicles and pedestrians. It was also envisioned that the electronics would be powered by the movement energy of the wheel.

In designing this product, two major issues had to be overcome: powering and controlling the LED lights. One idea for the power system was to use a weighted stepper motor to run as a generator. The body of the generator would spin with the wheel while the shaft of the generator was weighted to maintain the proper generator-continuous-spin action. This system would produce a sine wave generator output that could be rectified and regulated at a certain DC voltage. Under this configuration, it would be possible to power the LED circuitry on-the-fly. Another idea was to use a rechargeable battery which could power the electronics and be recharged continually by the generator. In this case, the unit would periodically shutdown for recharge by the spinning wheels. Also, there could be a temporary attachment to the car's battery and/or wall socket for recharging the system while the car was stationary. In general though, the team decided that the battery/recharging idea was a secondary solution and would only be considered if the on-the-fly concept was not acceptable in practice.

With respect to the control issue, it was determined that the sine wave coming from the stepper motor generator could easily be converted to a square wave with a simple Hex inverter that would be spatially related to the physical angle of the wheel. For example, a 200-stepper motor would give 200 sine wave periods in one revolution of the wheel, independent of the vehicle speed. Consequently, the clocking mechanism resulting from the stepper motor output could be used to control the LED lights. Triggering the LED's for the 200 stepper motor example should provide a persistently lighted image by repeating the process for every rotation of the wheel rim. Currently, the product team is using a programmable logic circuit to convert the spatially-related clock from the generator to the correct LED flash sequence.

The product team is also considering various attachment styles for the magic-rims. One method is a wheel attachment for existing rims that would include both a hubcap version and an attachment for custom alloys. Also, a fully integrated wheel is being investigated to include the magic-rim as an integral part of the manufactured wheel system. In this manner, the magic-rim wheels would retain the form, fit and function of a regular custom wheel that could easily be activated on-demand into lighted magic-rims.

Although the two team members have already graduated, the project is continuing and they have sought patent protection for their unique design concept.

UNDERGRADUATE ENTREPRENUERIAL PROGRAM

The development of a summer undergraduate engineering entrepreneurship program is also underway with two courses to be offered beginning Summer 2006. The purpose of this program is to introduce undergraduate teams to a similar experience of innovation and product development. One course will involve multidisciplinary teams evaluating, selecting, and developing a new product. The other course will introduce business and entrepreneurship concepts, including those concepts unique to technological products. Student teams will then be ready to develop a product prototype in their senior capstone design experience. The dual degree program partners will also be supporting this program by providing guest lecturers and half-time internships for some of the undergraduate students. Each student team will also include a

marketing student. Ideally, students completing the summer program will be ready to prototype the product in their senior culminating design course(s).

AN ENTREPRENEURIAL PERSPECTIVE

As the MS-MBA program strives to meet its goal of providing real world experiences in birthing and commercializing new products, the ability to analyze and address barriers to marketplace entry will be critical. This would include addressing existing barriers, while also establishing new barriers to entry. As briefly highlighted in the section on Lessons-Learned, one such key barrier to overcome is for student teams to address and secure intellectual property rights upon graduation from the program. And from an entrepreneurial perspective, the two main ingredients for initiating a new start-up company are the aspects of intellectual property and commercialization --- both of which will be described in more detail below.

Intellectual Property

Intellectual property can take on many forms including copyrights, patents, and trade marks or secrets. The key intellectual property issues that must be addressed for each student team as it progresses through the established format of the program are as follows:

- Ownership of intellectual property
- Establishing intellectual property
- Management of intellectual property

Initially, clear ownership of the intellectual property must be established. As industrial partners are introduced to student teams, this process will become even more critical to the eventual success of the new products that are developed. At a minimum, the goals of the student teams must be accounted for and managed as part of determining the proper ownership of intellectual property. If at all possible, the program should take an initial position that any intellectual property will be owned by the student team. If industrial partners are involved, the team will provide a right of first refusal licensing option to the partner as an initial offering.

The establishment of a patent position is dependent on the ability to patent. Patentable inventions must be novel, non-obvious, and useful. The patent process is lengthy and expensive. As such, the dual degree MS-MBA program must establish a support structure to enable the retention of intellectual property by the student teams. The University of Tennessee has a fully functional technology transfer office, The University of Tennessee Research Foundation (UTRF), that is responsible for establishing, managing, and marketing *university-owned* intellectual property. A working relationship has been established with UTRF to enable student teams to be successful in this area.

Commercialization

The experience of birthing and commercializing new products is a stated goal of the dual degree MS-MBA program. The ability to commercialize new products as they are developed will be directly tied to the student teams' ability to identify a customer and industry need as well as develop a product that fits this need. In addition, the size of the potential market will directly

impact the ultimate ability to successfully commercialize a new product. As such, the Product Selection and Evaluation process, discussed previously in the paper, is a critical component of the program. In addition, the ability to present product concepts to the entrepreneurial board and to leverage the participation of industrial partners will further the ability to commercialize products.

Commercialization of new products will occur through one of the following avenues:

- Student teams' interest in creating a new company
- Licensing of intellectual property to a third party
    - Industrial/private partners involved in the program
    - Other independent entity

In any of the above scenarios, the goals of the participating student team must again be a focal point. The goals of the student team should be incorporated into the chosen path of commercialization, especially as it is integrated with establishing intellectual property as noted above. It is again emphasized that the working relationship with UTRF, as noted above, should be a key support structure to enable this process. When meshed with the individual goals of the student teams, the commercialization process can become a viable avenue to not only enabling technology transfer to the private sector but also enabling the near term success of students who graduate from the program.

CONCLUSIONS

This paper provides an overview of the combined MS-MBA program at the University of Tennessee. As described in the paper, the graduates of this unique program will have the necessary engineering, management, and business skills to successfully integrate an increasingly complex body of knowledge for the rapid introduction of new products to the marketplace. The integrated program between the College of Engineering and the College of Business Administration at UT prepares its graduates for two different, yet closely related, career paths: one geared toward becoming an entrepreneur and initiating new start-up companies, and the other focused on taking a lead management role in existing companies where the forces of competition require rapid changes in design and manufacturing for a short product development cycle. Although the MS-MBA program at UT is still in its infancy, its curriculum and product idea base are continually being reinforced to promote an expanded enrollment and real-world relevance to product development and commercialization issues.