The New Product Design and Business Development Program: Engineers and Business Students Join With Industry to Create New Products

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I. Introduction

New products are the driver behind most successful businesses and the key to maintaining a competitive position in today's market. The University of Minnesota has launched an initiative which creates a novel educational model for teaching the principles of product design and development. The goals of this effort are:

1. To train future leaders of product design and business venture teams.
2. To improve the process of product design and business development through the understanding and development of new product design methodologies and entrepreneurial strategies .
3. To design new products and business opportunities for sponsoring companies.

The program represents a new partnership between the University and industry to advance the state of product design and business development. This paper describes the program, discusses essential issues for university-industry collaboration, and provides examples of projects undertaken to date.

II. Program Description

New Product Design and Business Development is a graduate level course offered jointly in the Carlson School of Management, the Institute of Technology, and the Department of Biomedical Engineering at the University of Minnesota. The course brings together students, faculty and representatives from client business firms to design and develop new products and business plans. Teams of six to ten students, half second year MBA's and half graduate level engineers, work together for the entire academic year (September to June) to develop a product and business concept. By June, each team is expected to deliver a working physical prototype of the product and an extensive business plan which details production, marketing and financial considerations for the product. Between four and six projects are undertaken each year.

The coaches for the teams include faculty from marketing, operations and entrepreneurial studies within the Carlson School, and from mechanical, electrical and biomedical engineering within the Institute of Technology. Additional coaching is provided by executives, managers and technical personnel from the sponsoring company. The coaches provide instruction in business creation, product design and product development, and have overall responsibility for seeing that the team sets appropriate, realistic goals and proceeds towards them on a timely schedule.

The project undertaken by the team must be selected carefully by the company in consultation with the course faculty to provide an appropriate educational experience for the students, to provide benefit to the company and to ensure the maximum chance for success. The general area of the product should be known, but specific product requirements should not be dictated to enable full exploration of market opportunities by the product development team. The project should have significant marketing challenges associated with it - in contrast to minor product line extensions - because student and faculty skilled in marketing are part of the team. The project should have significant engineering content - in contrast to clothing, books or paper clips - because skilled student and faculty engineers are part of the team. The product should come in discrete units - in contrast to food, material or petroleum products - because the latter are typically driven by process control issues. The products should be physical - in contrast to software, information or service products - to take fullest advantage of the talents and skill of the design teams and faculty coaches. (Although we did complete one software-based multi-media textbook project, and another project to develop a computer-aided engineering design tool.) Mechanical, electronic or electromechanical products, including those with embedded computers, are particularly good choices as are non-implantable medical devices given the expertise in medical device design at the University of Minnesota and the concentration of medical device companies in the Twin Cities area. Often, the best choice is a novel product which the sponsor would like to see developed but is in an area in which the sponsor does not have existing expertise, or is one for which there are insufficient resources to develop the product completely in-house.

Because the design teams work on real projects, issues of confidentiality and intellectual property must be settled well before the projects begin. A standard agreement form has been created and has worked well for most projects. Highlights of the agreement are that patent rights are assigned to the company, and that confidentiality is maintained, although students and faculty are free to publish non-confidential information about the project once it is completed. The confidentiality and intellectual property agreement with each company is signed by all students and faculty in the course, not just those on the project. This facilitates team interaction and enables the faculty and students to generalize what is being learned from each project. We have found sharing information to be one of the best methods for learning about and improving the product development process, and the company has the benefit of many more students and faculty thinking about their product. Because confidentiality and intellectual property issues can make or break programs like ours, the agreements are described in more detail in a following section.

Sponsoring companies pay a project fee of $25,000 to partially offset the instructional costs associated with the course. Independent firms with total revenues of under $1 million per year pay a reduced fee of $10,000. In addition to the project fee, the design team will incur project costs to conduct marketing surveys, hold focus groups, construct prototypes and produce reports. We suggest that the sponsoring company support all expenses associated with these and other activities at the same level as it would if the team were internal. Company resources such as internal prototyping shops should also be available for use by the team when appropriate. Additionally, it is beneficial to send one or two of the student team members to an industry trade show relevant to the project. Each time a major cost is anticipated, the team, including company liaisons, determines if that cost is appropriate. Projects incur many incidental costs as well, for example, report printing and long-distance telephone calls for information gathering. Each team is provided with a small discretionary fund out of the course budget to cover expenses that are course, but not project related, or for small purchases that are needed immediately and would take too long to clear company purchasing channels.

The responsibilities of the company sponsors are to: (1) be committed to the project and prepared to support the team's activities, (2) provide marketing and engineering liaisons to work closely with the team, (3) share company information freely with the team when needed for project progress, (4) support appropriate project prototyping and marketing expenses, (5) have realistic expectations about results.

Good product design requires knowledge of the market, past design efforts, patent positions, manufacturing capabilities, financial expectations and other information. As much as possible, the company should share this information freely with the design team. For example, the team may request information to help them generate financial forecasts for the new product. Here, it is helpful for the company to provide the team with a spreadsheet containing data for a current product which shows how such forecasts should be computed and formatted. Withholding information under the philosophy that, "well, the students should learn by figuring everything out for themselves", is a bad idea. The more the company shares with the entire team, the more chance for success.

The deliverables at the end of the nine months include one or more working prototypes, a detailed engineering report and a comprehensive business plan. Although the students are expected to perform at a level that will result in substantial benefit to the company, no guarantees can be made, and the company must have reasonable expectations about outcome. It is important to realize the main purpose of the course is to provide an appropriate educational experience to the student rather than a direct service to the company. If the company needs guaranteed deliverables, a better approach would be to develop the product internally or to contract with an independent market research or product development firm. Initial goals are set for the project early in the Fall Quarter. Based upon past experience, project directions and goals often change after new information is learned from the market or new technology is developed. This is a normal part of the product development process and projects which follow best practices will have the flexibility to change direction without endangering the project mission.

III. Confidentiality and Intellectual Property Agreements

The confidentiality part of the agreement between students, faculty and the sponsoring company obligates the signers to prevent disclosure of confidential information that is revealed to them by the company. Confidential information may take the form of product concepts in existence at the company, market survey information or design drawings and reports. We take care that all such information is clearly marked as "Confidential" and every effort is made to limit the transfer of information to only what is required for the team to be successful on the project.

Some of the implications of the confidentiality clauses of the agreement are:

1. Students and faculty cannot disclose confidential information to friends, family (including spouses), or faculty not involved in the course. In short, students are prevented from revealing the information to anyone who has not signed the agreement.
2. The agreement is between the student and the company, not between the university and the company. Further, the University of Minnesota's legal office will not be able to represent students in cases of litigation.
3. The agreement has a five year time limit.
4. Students and faculty must maintain information confidential up until the time limit even after the course is over and even after students graduate from the university and work in industry (possibly for a competitor). This also means that students are not be able to discuss details of their project work with potential employers during job interviews. Students are, however, able to give prospective employers an adequate description of their activities and the skills they learned provided that nothing confidential is discussed.
5. Faculty and students may publish results from the work, but any publication resulting from the project will be screened by the company to ensure that it contains no confidential information.

The intellectual property portion of agreement covers what happens to any patentable ideas that are develop as a result of working on the project. The agreement requires that students and faculty assign their patent rights as named inventors to the sponsoring company. Because the design teams are large, it is likely that patentable ideas will result from the contributions of more than one team member. The Patent Office has a strict definition of who appears as named inventors on a patent and it is those named inventors who will be assigning the patent over to the company. Some of the implications of the intellectual property clauses of the agreement are:

1. A student or faculty member can be a named inventor on a patent even if patent ownership is assigned to the company.

2. Because rights are assigned to company, students are not able to make, use or sell any product they invent. Only the company may do so.
3. The company will pay all costs and fees associated with patent filing. These commonly run in the thousands of dollars.
4. Ideas, concepts or methodologies developed by the design team may have potential for significant increase of sales or cost savings by the sponsoring company. The company is free to pursue those ideas without returning monetary rewards to the student inventors, nor to the University.

IV. Program Features and Highlights

There are several features of the program which make it somewhat unusual and helped to contribute to its success. One of the most important is that the projects are real. Projects are taken on only if the company has committed to manufacture the future product. This should be contrasted with our senior capstone design course which also runs industry sponsored projects, but typically the results of those projects are not as closely watched by the company.

The mix of engineering and business students is a major highlight. Projects are run with true cross-functional teams and the engineers are encouraged to take on marketing tasks and vice-versa. As faculty, we are rewarded when we see a business student sketching ideas in a brainstorming session or making a part on the lathe in the Mechanical Engineering student shop, or to see an engineering student conduct a customer interview or run some profit forecasts on a financial spreadsheet. We do not expect engineers to become expert marketers or marking students to become engineers, but for success in product development, each team must learn from the other.

The interaction with the company is substantial. Two or more company representatives from marketing and/or engineering attend the weekly team meetings held on campus. Companies have spent thousands of dollars fabricating prototypes or supporting professionally moderated focus groups, all part of normal product development costs. In many projects, students spend considerable time at the company, particularly in the final weeks. Towards the end, as the project is gradually handed off to the company, more and more work is done by company staff working alongside the students. Final presentations held at the company site have drawn up to 20 company representatives, including CEO's and VP's. All of this is convincing evidence that the company cares about the result of the project.

The confidentiality and intellectual property agreement is the key which enables the university to participate in real projects with companies. Settling on a form for the agreement required substantial negotiations between lawyers for the companies and those for the university. Universities have no hold over student work done for courses, but it is unusual for the university to allow a contract where faculty assign their rights to a company since faculty are employees of the university. Nevertheless, all parties agreed that this was necessary to enable a substantial learning experience for the students.

Faculty have used the course as a “laboratory” to conduct research on the product development process. The projects are sufficiently real that meaningful studies can be conducted. For example, one study looked at communication between marketing and engineering members of a cross-functional team, and analyzed e-mail and meeting transcripts to determine how each viewed the other, and drew conclusions on how the quantity of cross-functional communication affected project outcome [1].

The revenue from company participation fees supports some of the instructional costs of the program, which admittedly is faculty intensive. The remainder of the fees have been used to support and augment the design infrastructure. For example, the university paid for part of a rapid prototyping machine and purchased a number of toolkits for an undergraduate introduction to engineering course from course revenues.

V. Projects

New Product Design and Business Development started in the 1994-1995 school year. As of the end of 98-99 we have completed 25 projects, and over 150 graduate students from business and engineering have participated along with 8 faculty. Several patents are being filed by the companies and many working prototypes developed. We have worked with small startup companies such as Soil Sensors which has five employees and makes a soil moisture sensor for precision farming, and with companies as large as 3M with thousands of employees. Products have ranged from a smart clutch-brake system for Horton Manufacturing to a controlled-motion electronic integrated circuit testing machine for Aetrium Inc. to a micro-endoscope for Micro-Medical Devices.

In 1997-98, the 3M Post-it Flag group approached the university to work on a project. The challenge was to find new, innovative products for Flags which could increase sales, possibly by opening new markets. The team of students, faculty and 3M representatives generated approximately 200 concept ideas at the level of index card sketches, built about 40 prototypes and narrowed selections down to four or five final ideas realized in refined prototypes. Along the way, voice of the customer information was gathered through dozens of one-on-one interviews and four professionally moderated focus groups. Sales forecasts were sufficiently encouraging that 3M will soon go forward with a placement study now that the project has been fully handed over to the 3M team.

In another project, a team working with Augustine Medical, a medium size medical device company specializing in products which keep patients warm during surgery, examined new markets for the company's core technology. That new market was identified and clearly defined in the final business plan, and several prototypes built and trial tested in the field. Augustine Medical officials stated that working with the team saved them 1-1/2 years in the product development cycle.

Another recent project was conducted with Sulzer Medica, a Swiss Company that is the leading European manufacturer of joint implants. The project entailed developing a new product to facilitate hip surgery. Having a sponsor several thousand miles distant highlighted the advantages and disadvantages of e-mail, fax, phone and video-conferencing communication media, all of which were used. To further complicate matters, the product is intended to be introduced in Europe first, but it was difficult to gather voice-of-the-customer data from European orthopaedic surgeons because of the distance. Nevertheless, the team took some risks and developed a working prototype that Sulzer will take on to manufacture, and a detailed business plan covering the product introduction in both European and American markets.

VI. Conclusions and Lessons Learned

New Product Design and Business Development has been successful in all three of its objectives. First, business and engineering product development leaders have been trained because students experience the full product development cycle in a realistic setting. Many of our graduates have gone on to product development positions in companies. Second, research results are just starting to be generated from the product development process studies conducted in parallel with the projects. Third, companies are benefiting from the creation of real product prototypes and real business plans.

Along the way, we have learned several lessons that might be of interest for those considering similar programs:

- Engineering and business must lead the program equally. Ours is not a program out of the engineering school with a business component added, nor a program out of the business school with some engineering added, but rather is led by both schools. This has two advantages. First, a total development process can be followed, rather than just marketing or just engineering. Second, faculty and students can learn from their new colleagues who are nominally in different areas, but who can find common ground in new product development process.
- Creating appropriate confidentiality and intellectual property policies and agreements takes time and requires considerable negotiation between company and university lawyers. Faculty and company product managers must stay in the loop to make sure the final agreement makes good sense. Once an agreement has been reached with one company, use it for all companies since multiple agreement forms or allowing companies to modify agreements just leads to endless rounds of negotiations.
- The formal academic component of the course should center on learning a product development process. This is what differentiates the course from a work-study program or company internship which does not require formal academics. Through targeted lectures and readings, we advocate a total development process, from needs identification through product launch and beyond. By absorbing the didactic instruction and by observing all teams working, students can generalize beyond their own specific projects to deepen their understanding of product development process.
- The closer geographically the company is to the university, the greater will be the company interaction. We have worked with many companies in the Twin Cities area and most participate fully. Projects whose sponsors are in different parts of the country or in different countries tend to evolve into an "over-the-wall" format where the company hears about results at a final presentation rather than being a part of the team during the development process.

VII. Additional Information

Additional information on the New Product Design and Business Development Program, including copies of agreements with companies, can be found on the program Web site: www.me.umn.edu/courses/me8250.

References

[1] Dooley, K., W. Durfee, M. Shinde and J. Anderson, A river runs between us: Legitimate roles and enacted practices in cross-functional product development teams, *Advances in Interdisciplinary Studies of Work Teams: Product Development Teams*, Vol. 5, JAI Press, 1999 (in press).

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