Teaching Innovation as Part of an Agribusiness Curriculum

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The business landscape which agribusiness graduates will enter has been characterized as one with rapid change, an ultra-competitive environment and high uncertainty (Ross and Westgren, 2006). Creating graduates with the capacity to meet the challenges of the agribusiness environment is a challenge faced by agribusiness programs. Rapidly changing, ultra-competitive, uncertain environments require that agribusiness graduates be taught how to manage and implement strategic innovation. The themes of this paper are 1) strategic innovation management can and should be an important and integrated part of agribusiness programs; 2) innovation is by nature a cross-functional/multidisciplinary endeavor; and 3) innovation will be best taught by causing students to experience real world innovation problems.

Strategic Innovation Management

To understand “strategic innovation management”, we must first develop a working definition of innovation. Not everyone agrees as to the meaning of the term “innovation”. Murphey and Davis, 2006, suggest that innovation involves more than creating a novel technology, idea or prototype and suggest that innovation requires that the product be taken to market. Erlich (2007) defines innovation as “the process by which new ideas enter the economy and change what is produced, how it is produced, and the way production itself is organized.”

Schumpeter (1934) identified five types of innovation: 1) utilizing new and cheaper sources of supply, 2) developing a cheaper substitute, 3) creating a new good that more adequately satisfies existing and previously satisfied needs, 4) the search for new markets and 5) the introduction of a completely new product. Note that, in each case, Shumpeter suggests that innovation involves some form of implementation of the creative idea and does not end with idea creation. Similarly, Ross and Westgren (2006) emphasize that innovation involves implementation of the creative idea when they suggest that gains from innovation can occur from saving capital, saving labor or both. Successful innovation requires that novel ideas or products actually be developed, brought to market and adopted. (Tucker, 2002)

Other views tend to equate innovation with creativity. For example, Amanor-Boadu (2006), suggests that entrepreneurs are agents who spot and seize innovations and purposefully transform them into desired outcomes. Implicity, Amanor-Boadu is suggesting that the innovation process does not include transforming the development into desired outcomes (business implementation).

The separation of the creative component of innovation from business implementation is a mistake according to Sawhney, Wolcott and Arroniz (2006). Sawhney, Wolcott and Arroniz claim that many companies have a mistakenly narrow view of innovation which includes only new product development or traditional research and development. “A great product with a lousy distribution channel will fail just as spectacularly as a terrific new technology that lacks a valuable end-user application.” They suggest twelve dimensions of business innovation including offerings, platform (common components), solutions (i.e. John Deere’s integrated array of products and services), customers (new customer segments or unmet needs), customer experience, value capture, processes, organization, supply chain, presence (distribution channels), networking, and brand. These dimensions may be intertwined and interrelated within the business.

Our conclusion is that innovation involves developing creative new products, services or techniques that contribute to a company’s profitability. This definition is very close to those of

Carlson and Wilmot (2006), Tucker (2002), and Erlich (2007), and is consistent with Schumpeter (1934), and Sawhney, Wolcott and Arroniz (2006).

"Strategic innovation management" suggests that the process of developing creative ideas that result in successful products or services is a decision (strategy) that firms can adopt. The firm then plans, staffs, directs, controls, and organizes to implement the decision.

We view innovation as a strategic decision because there are ways of managing a firm to create a business in which innovation flourishes. Market evidence in the form of successful management consulting firms that regularly help companies be more innovative suggests that management of innovation can be enhanced (see for example SRI's Innovation Partnership Program, http://www.sri.com/innovation/index.html or Doug Hall's Eureka! Ranch program, http://www.eurekaranch.com/).

The academic and business communities are not unified in a belief that innovation and entrepreneurship can be taught. In a 2006 article, Klein and Bullock asked whether entrepreneurship, including Schumpeterian innovation could be taught. They concluded that while some aspects of the entrepreneurial function and process could be taught, many more could not be taught. Characteristics attributed to successful entrepreneurs have included boldness, imagination, creativity (Begley and Boyd 1987; Chandler and Jansen, 1992; Lumpkin and Dess, 1996), the ability to articulate a plan or vision and impose it on others (Witt, 1988), and alertness to profit opportunities (Kirzner 1973, 1979, 1992).

McGrath and MacMillan (2000) argue that this entrepreneurial ability is developed through experience and therefore probably can't be fully learned in a classroom. However, even if one subscribes to the view of McGrath and MacMillan, this doesn't necessarily preclude teaching through experiential learning and simulation.

According to Klein and Bullock (2006), "An increasing number of entrepreneurship courses focus…on identifying opportunities for creating new sources of value. Opportunity identification involves not only technical skills like financial analysis and market research, but also…creativity, team building, problem solving and leadership (Long and McMullan, 1984; Hills, Lumpkin and Singh, 1997; Hindle, 2004). It can involve both the recognition of already existing opportunities and the creation…of new opportunities (Alvarez and Barney, 2005)…Opportunity identification is typically taught through innovative problem-solving and creative-thinking exercises." While we appreciate the challenge of teaching innovation and entrepreneurship, it is clear that those in the business community are having success selling programs to improve innovation and therefore our working hypothesis is that innovation can be taught.

Need for Strategic Innovation Management in Agribusiness Programs

One implication of our definition of strategic innovation management is that to be successful, programs that embrace innovation education will by necessity be multi-disciplinary. It is not enough for the scientific/engineering staff of an organization to independently develop a new product and toss is out of the laboratory to be marketed, financed, and sold to customers. Carlson and Wilmot (2006) and others clearly suggest that integrated cross-functional (multi-disciplinary) teams are required and desirable.

Many agribusiness firms are manufacturers. Manufacturing groups have clearly recognized the need for learning best practices in innovation management and suggest that there are dire consequences if we lose our leadership in innovation management. Some of the blame for loss of leadership is also being placed, correctly or incorrectly on universities.

Popkin and Kobe (2006) suggest that innovation is the cornerstone of the survival of U.S. manufacturing, but current leadership in innovation is at risk. Regularly, the popular press and journals (i.e. Lin, 2005; Popkin and Kobe, 2006; Kahn et al. 2006; Mentzer, et al., 1999; Dooley et al., 2002) assert U.S. manufacturers and the associated work force are not innovative nor are universities preparing the future work force to be innovative. The consequences of losing leadership in manufacturing innovation are severe. Popkin and Kobe (2006) suggest the U.S. will experience: 1) a reduction in research and development (R&D) expenditures by manufacturing firms; 2) reduced capital investment in the U.S.; 3) reduced wealth generation; and 4) a reduced number of manufacturing jobs (research and development as well as production). The loss of manufacturing jobs in the U.S. is well documented (Brauner, Congressional Budget Office, 2004; Wojan, 2005). According to the 2003 and 2005 *Annual Survey of Manufacturers* reports released by the U.S. Census Bureau, 564,405 manufacturing production worker positions were lost nationally during that two year period.

The call for programs to teach future professionals to address innovation problems faced by small- and medium-sized manufacturers (SMMs) in the U.S. is clear. The performance of all of U.S. manufacturing is tied more than ever to the success of SMMs and particularly to SMMs becoming more innovative. Further, SMMs frequently lack the cross-functional (multi-disciplinary) expertise or resources necessary to introduce and commercialize new products successfully in today's global market.

A substantial literature in new product development is evolving and best practices in new product development have been written, criticized and evaluated (Adams-Bigelow, 2006; Cooper 1979, 1994; Cooper, Edgett and Kleinschmidt, 2004a, 2004b; Cooper and Kleinschmidt,1987, 1995; Cormican and O'Sullivan, 2004; Dooley, Subra, and Anderson 2002; Griffin, 1997;

Griffin and Page, 1993, 1996; Henard, and Szymanski, 2001; Kleinschmidt, 2006; Kuczmarski, 2006; Notargiacoma, 2006). The existence of and interest in best innovation practices suggests that people think they can be learned and may be useful to product managers.

Companies are also recognizing the benefits of cross-functional, multi-disciplinary teams. Von Oetinger (2004) cites examples of businesses that have brought together teams of people from various backgrounds and experiences to improve innovation success. A fresh perspective may help identify what is wrong with an existing product or where a new niche may lie. At Monsanto, innovation-related units have two usually co-equal leaders from two different parts of the organization. For instance, a unit planning the introduction of a new pest-resistant variety of potatoes might have a head from marketing and one from R&D. At Monsanto, repeated creation of teams with people from many parts of the business and sometimes even outside the firm, helped to keep the innovative ideas fresh (Wood, 2007).

A concept called "open innovation" that is gaining momentum in the food industry involves collaboration with key suppliers, customers and even partners in different industries. Many new developments are coming from small, innovative companies. In 2005, General Mills identified open innovation as a key strategic priority and formed a cross-functional innovation team to seek alliance opportunities (Erickson, 2008).

Improving the performance of new product teams requires speeding up the product development process. Interdisciplinary teams are a possible mechanism for this. "Much of the delay in product development comes from the difficulty in coordinating the efforts of various groups that must contribute to the development of a new product." (Ancona and Caldwell, 2007) Many examples can be found where product design failed to incorporate adequate consideration of manufacturing or marketing issues. Multi-disciplinary teams have the potential to improve coordination and allow project work to be accomplished in a parallel rather than sequential fashion. In order to effectively use cross-functional teams, the organizational structure and reward system may need to be modified.

The challenges of innovation are not unique to agriculture or agribusiness. In 2006, the American Association of Universities proposed a National Defense Education and Innovation Initiative to meet America's Economic and Security Challenges in the 21st Century. Key recommendations included strengthening the connections between campus-based research and undergraduate education and establishing interdisciplinary research and education initiatives that create new combinations of faculty and students.

Other disciplines are also recognizing the need for more emphasis on innovation. In 2004, the U.S. Department of Health and Human Services (HHS) created a Task Force to encourage innovation in healthcare. In the justification for the program, the department said, "Recent advances in basic sciences, such as genomics, proteomics, and bioinformatics, have created the potential for the development of innovative medical technologies that can provide new hope and better quality of life for many Americans…Nonetheless, there is concern that (despite record levels of public and private investment in research) new discoveries are not rapidly translating into new medical products for patients." (HHS, May 24, 2004 Federal Register notice) Similarly, in developing the NIH Roadmap to identify and address key issues in speeding the translation of new scientific discoveries into medical technologies, NIH Director Elias Zerhouni said: "There has been a scientific revolution in the last few years the opportunities for discoveries have never been greater, but the complexity of biology remains a daunting challenge."

University Responses for Assistance in Innovation

In a speech to the National Governor's Association, Erlich (2007) asked the question, "How does the university system relate to the challenge of innovation and entrepreneurship?" He suggested that technology has changed the ways in which people solve problems, placing a greater premium on the ability to harness facts using judgment, intuition, and creativity, to work in teams and to integrate diverse subject matter.

Universities and Government agencies have recognized the need for increased innovation. Various approaches have been attempted. Our review of these centers is intended to be illustrative but not exhaustive.

One approach to encouraging innovation in agriculture has been establishment of innovation centers associated with universities. Some of these innovation centers operate business incubators. Most provide education, and technical and business planning assistance to small businesses. Feasibility studies, packaging, nutritional analysis and market analysis are among the services frequently provided.

The 2002 Farm Bill authorized establishment of USDA Agricultural Innovation Centers. Such centers were established at Purdue, Michigan State, Kansas State, Penn State, Rutgers, and Cornell. Other centers were established in Iowa, Minnesota, and Montana (Ag. Marketing Resource Center). Established even earlier, the Robert Kerr Food and Agricultural Products Development Center at Oklahoma State University helps innovators with product development and testing as well as business and marketing plans. Other types of centers include the National Center for Food Safety, the Dairy Research and Information Center and the Robert Mondavi Institute at the University of California, Davis, and Food Processing Centers or Pilot Plants at Washington State University and the University of Nebraska-Lincoln. Recently, the Kansas Biosciences Center of Innovation has provided a planning grant for The Kansas Innovation

Center for Advanced Plant Design. Many of these centers involve collaborations between economic development agencies, universities and state and federal government entities. The goal is generally to increase business growth within the particular state and sector.

Another approach utilizes competitions, incentives and venture capital assistance to encourage development of new product ideas. An example of this is Innovation Quest at California Polytechnic State University (2008). Projects are judged based on potential for commercialization, development of a prototype validating the novel idea and a business plan for taking the product to market. People are encouraged to work in interdisciplinary teams to develop the ideas. Awards are given to students or faculty members with novel ideas. The project was founded by a faculty member and retired executives from Cisco Systems and Network Appliance. The amount of funding is relatively small ($5000-$15,000 for the three best ideas), but other forms of assistance are also available.

A similar program, the Intel-Berkeley Technology Entrepreneurship Challenge (2008) promotes entrepreneurship globally. In 2007, they hosted 21 teams from 11 countries with the winning team receiving $25,000 and interaction with leading venture capitalist firms. In 2003, the U.S. Environmental Protection Agency and other government and industry partners launched the P3 Award to promote innovative thinking on issues of sustainability. Student teams compete for $10,000 grants which are used to develop design projects. In the spring, the National Academies evaluate the projects and the highest-rated student designs receive additional funding up to $75,000 to further develop the designs and move them to market. Many business schools, such as that at Purdue University and the Kellogg School of Management at Northwestern University have annual business plan competitions.

What have other universities tried? Although many MBA programs have courses in entrepreneurship and innovation, our emphasis for purposes of this paper is on opportunities for undergraduate students. At Purdue, a student club, Purdue Innovations (Purdue University, 2008), was formed to give students hands-on experience in "exploring the feasibility of business ideas" and an opportunity to work toward turning ideas into business ventures. Students have opportunities to network, share ideas, meet experts, identify resources, and develop business plans.

At the University of Western Kentucky, a Center for Entrepreneurship and Innovation (University of Western Kentucky, 2008) is an interdisciplinary program that attempts to educate students through classroom curriculum, experiential learning and research. They also provide assistance to small businesses. Courses in the business curriculum include Entrepreneurship, Entrepreneurial Finance, Entrepreneurial Marketing and Innovation Management. Aurora University offers both B.A. and B.S. degrees in Management and Innovation as well as a minor in that field. The program includes one course in Entrepreneurship and Venture Initiation and one course in Innovation.

Engineering programs have also become interested in ways to better prepare engineers to work in innovative design teams. The Accreditation Board for Engineering and Technology (ABET, 2005) criterion 3c requires that engineering programs demonstrate that students attain "an ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability." Criterion 3(h) requires that students be able to "understand the impact of engineering solutions in a global, economic, environmental and societal context".

Multidisciplinary capstone design courses are ideally suited to accomplish these goals. The College of Engineering at the Rochester Institute of Technology has a three quarter sequence that works on multidisciplinary teamwork, problem-solving, innovation, entrepreneurship, market-oriented product development focus, technical communication and consideration of multidisciplinary design constraints (Carrano and Thorn). Other institutions have senior engineering capstone courses that attempt a multidisciplinary approach. However, these multidisciplinary courses don't usually involve team members from outside the engineering disciplines. Consequently, the knowledge base and perspectives are still limited by what is taught in an engineering curriculum.

Truly interdisciplinary senior projects that involve faculty and undergraduate students from engineering, business and communications departments are rare. It is not unusual for master's programs in business to target engineering graduates. Business concepts have been taught in engineering curricula; Ph.D. students in engineering are being encouraged to work with management students in the Innovation 101 NSF-sponsored program at Purdue, and numerous universities have developed master's degree programs in technology management, entrepreneurship and innovation management. Most of these programs share the objective of improving the capacity of students to participate in innovative firms that will encourage economic development (Tan, Lim, and Toh, 2000).

The University of Colorado at Colorado Springs offers Bachelor of Innovation degrees in Business Administration, Computer Science, C.S. Security, Electrical Engineering and Games Design and Development. The program is an interdisciplinary effort between the College of Engineering and Applied Science and the College of Business. The program includes a multi-year, multi-disciplinary team experience working on real problems with local companies.

Students learn about business, policy, intellectual property, globalization, communication, technology and sustainability issues. Students in the business curriculum take 27 credits in the innovation core, 21 credits in either the engineering core or globalization core, and 42 credits in the business core. Students in all programs choose 21 credits from one “cross over” area: 1) Technology, 2) Business, 3) Globalization or 4) Creative Communication (University of Colorado, Colorado Springs, 2008).

An Interdisciplinary Senior Design/Capstone Approach

The focus of our paper is an approach which involves considering ways we can improve innovation education. Some aspects of the discussion will include entrepreneurship because entrepreneurship can incorporate innovation. Our search has found that courses in entrepreneurship are much more common than courses specifically focused on innovation. Entrepreneurship classes are relatively common in business schools, especially at the graduate level. What lessons could we take from those courses and apply at the undergraduate level in agribusiness?

How do we prepare students to work in innovative businesses?

The separation of engineering/technical components from business and marketing communications components effectively removes the possibility that innovation best practices will be learned, experienced and implemented by undergraduate students nearing graduation. As previously noted, many agribusiness firms have already adopted cross-functional, multi-disciplinary teams. If we do not teach students how to work on multi-disciplinary innovation teams, firms cannot expect new employees from colleges and universities to have any real understanding, appreciation, or skills directly applicable to strategic innovation processes. Without this interdisciplinary experience, economic, marketing and communications considerations likely will not influence new engineers in designs of products or processes. Companies are less likely to commercialize a new product development if the marketing, communications, financial and management issues associated with the product have not been analyzed.

The opposite is true for business and marketing communications students. They are taught that creativity happening in their own disciplines on a project is of premier importance, and they take creativity in the technical aspects as a given and separate from their own work. As such, they miss the real opportunities for synergistic innovation and basic understanding of the innovation process. By working hand-in-hand, engineers, business specialists and communications specialists mutually will influence all project outcomes.

We have developed a pilot project which involves collaboration between Agricultural Economics and Agribusiness programs, as well as Engineering and Communication programs at Oklahoma State University, the University of Nebraska, and California Polytechnic State University. The objectives of the project include: 1) creating work-place-ready graduates who are capable of participating in and eventually leading private sector innovation, 2) enhancing the educational experience of students in agribusiness, engineering and communications programs so the number of majors in those disciplines will increase; and 3) developing and disseminating interdisciplinary curricula that can be adapted and used by other universities to implement similar problem-based, experiential-learning activities.

The curriculum will be designed to teach students how to come up with ideas **and** bring them to life. The process by which value is created for customers by transforming knowledge and technology into profitable products and services for which there is a market will be included in the curriculum (Milbergs, 2004). The project involves 12 faculty members from eight different departments at three universities.

Each program will utilize a 3-course capstone sequence which involves first an innovation course, followed by 2 quarters or semesters spent working on an interdisciplinary team in conjunction with a company to solve a real-world problem. It is anticipated that students will incorporate global and sustainability issues affecting design and business planning and will learn to communicate about innovations and plans within the team, as well as to the client companies and potential customers. The ability to think strategically, to understand issues from other perspectives, and to understand professional and ethical responsibility will be included in objectives for participants. The pedagogy will be problem-based and experiential and will embrace innovation as a *process*.

This project is based on the theory that innovation performance of firms can be improved through education and increased interactions of the firms and their employees with university students and faculty. Support for the relationship between university research and innovation is widespread (Mowery and Sampat, 2005; Kim et al.., 2005; Costa and Teixeira, 2005; Baek and Jones, 2005; Tan et al., 2000). Numerous studies have examined the relative importance of environment, strategy, and/or market orientation on firm performance (i.e. Pelham, 1999; Pelham and Wilson, 1995; Langerak et al., 2004; Yoon and Lilien, 1985; Montoya-Weiss and Calatone, 1994; Baker and Sinkula, 1999a, 1999b; Gastignon and Xuereb, 1997; Drazin and Schoonhoven, 1996; Dwyer and Mellor, 1991; Henard and Szymanski, 2001).

The project activities will involve selected students in a class on innovation that includes tours of innovative manufacturers, optional summer internships with manufacturing companies, and participation in a two-semester capstone/senior design course during their senior year. The project will create curricula in which cross-functional/interdisciplinary student, faculty and industry teams address new product innovation and implementation in real-world companies. The student team members will present (in writing and orally) proposed solutions to technical, business and communications issues associated with innovation in a company. Students, faculty and client companies will experience the complete process of innovation including product development and commercialization.

Students will apply for participation in the program during their junior year. Each university will recruit 18 to 24 students per year from disciplines in engineering, business and communications. Selection criteria will include the following areas:1) academic performance and classes completed, 2) interest in careers with manufacturing firms, 3) interest in the project, 4) time available for the project, and 5) faculty recommendations. Efforts will be made to attract applicants from under-represented groups. The selected students will take a class in spring semester of their junior year or fall quarter of their senior year that will introduce them to innovation processes and integrated product development.

At the beginning of the class, students' knowledge of innovation, product development and innovation capacity will be assessed. This class will expose the scholars to innovative companies in Oklahoma, California, Nebraska and the U.S. and introduce them to literature about innovation in manufacturing. The classes will tour companies that will include possible collaborators. Students will participate in optional summer internships with companies. The senior design/capstone course will be fall and spring semesters of their senior year at UNL and OSU (Winter and Spring Quarter at CPSU).

During the senior design/capstone course, a technically feasible product for which there is a market will be the subject of the innovation exercise. Along with devising a technical solution to the problem, students will develop a business plan for the new product. The plan will include a marketing plan for the product, an analysis of the financial issues (potential profit, rates of return, cash-flow analysis) and the human resource requirements to commercialize the product. Students will create a marketing campaign for the product, including materials for product displays, advertising, public relations, trade shows and Web-marketing efforts. The final written and oral presentations by the interdisciplinary student teams will include all aspects of the innovation, including a technical design and working prototype, a complete business analysis and a complete design of a marketing campaign.

The approach will cause engineering students to focus more on practical manufacturing issues, the costs of manufacturing, customers' needs, and communications issues as they go through the product design process. Business and communications students will become more aware of the technical issues that must be resolved before a new product concept will exist. As part of cross-functional teams, all participants will have a joint responsibility for all outcomes.

This approach is consistent with innovation best practices recommendations. Innovation education and the probability of successful implementation of a new product are enhanced if product engineering and design, business planning, and communications issues are approached simultaneously rather than sequentially and if the innovation process evidenced by best practices is thoroughly understood.

The students' capacities to integrate multidisciplinary concepts and apply them to real-world problems will be assessed at the beginning of the first semester/quarter when the participation in the project starts, two times during the course and at the end of the year. The formal assessment instrument will be modified from those suggested for laboratory and discussion classes (National Research Council, 2003, pp. 157-162). Because of the weekly, out-of-class contact with students in small-group, interdisciplinary meetings, informal feedback will be frequent. Faculty will interact regularly with students about progress on the class objectives and to determine project progress. Faculty will be in regular contact with client companies to determine whether the preliminary reports/deliverables produced by the students are meeting company objectives and expectations. Final project deliverables will be presented in both written and oral formats to the course instructor, project sponsors, industry representatives, faculty from CPSU, OSU and UNL, students, and guests. Each class will travel at least once to visit and interact with students, faculty and client companies at the other participating universities. Additional interaction will be accomplished with video conference calls and other technology. Each project team will present its work at the end of spring semester/quarter. Those in attendance will evaluate and assess each team's presentation and project. In addition to the evaluations of the final project presentations, students will be assessed based on the course assignments and reports, other oral presentations, general class participation, and peer feedback. The reports and presentations prepared by the student teams are evaluated in the areas of technical content, creative application of knowledge, teamwork, student-client interaction, communication skills, business and financial analysis, marketing plan, and overall professionalism.

Faculty and curricula assessment will include written and oral student evaluations as well as peer evaluations from other participating faculty, participating client companies and departmental advisory groups.

Each cooperating company at each university will receive a final oral and written report from the student teams. In many cases, plans and an operating prototype product will be delivered to the client companies. Faculty experience with teaching single discipline courses involving companies as clients suggests many suggestions and recommendations contained in student project reports are implemented by the companies. Better products designed through an integrated process, business plans and communications materials should produce company reports with more characteristics that can be implemented by the client companies.

The three-university proposal makes it possible to have motivated, critical, constructive reviews from faculty who understand the goals and objectives of the project. Specific evaluation plans include the following:

- Pre- and post-experience evaluation instruments will be used to make quantitative assessments of the degree to which student participants improve their analytical, problem-solving, computational, and decision-making skills and abilities;
- Post-project focus groups of students will be used to assess qualitatively the impact of the students' experiences on their interpersonal, leadership, and communications skills and abilities;
- The oral and written project reports, materials and prototypes companies receive will be evaluated by participating company representatives, faculty from other participating universities, other faculty in participating departments, and other students participating in other projects;
- Mid-project (after the first class is completed) and post-project review by a team of external reviewers (the review team will include representatives from CSREES, ABET, faculty from a non-participating university, and manufacturing product managers);
- Interviews of graduates who complete the program (and a paired sample of those who did not) after they have been employed for a year and an assessment of how participation in the program influences career success; and

- Post-project reviews to determine whether company participants implemented recommendations contained in the student project reports.

Project faculty from all three universities frequently and regularly work on company projects as class projects. Each of the companies becomes a collaborator for its specific project. In some cases, companies have supported more than one project. The three-university proposal makes it possible to have motivated, critical, constructive reviews and interchange available to review programs at other participating universities. In addition, each student project at all three universities will be evaluated by participating company representatives as well as external leaders in manufacturing.

Conclusions

Combining innovative technical assistance with innovative marketing, communications and overall business planning is necessary to create effective cross-functional innovation strategies for manufacturers. Cross-functional manufacturing innovation strategy development is inherently interdisciplinary and essential for successful SMMs. All too often, the first time university graduates experience interdisciplinary issues faced by a manufacturer occurs when they join a firm. Students who participate in a cross-functional innovation strategy development as undergraduates are more likely to be ready and prepared to be involved actively in successful manufacturing innovation. Universities and educational programs frequently are organized with disciplinary boundaries that do not allow students to experience interdisciplinary approaches to practical problem solving in manufacturing. Disciplinary boundaries at all three universities are breached in this project.

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