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Making Industry Meaningful In College for Technical Students

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A multi-disciplinary project at Illinois Valley Community College provides electronics and engineering design students with training and practice with the entire process of manufacturing, continuous quality improvement, problem solving, leadership, teamwork and communication in a simulated industrial setting. Entitled Making Industry Meaningful In College (MIMIC), the entrepreneurial project places students in electronics, engineering design and various business fields into teams, called "companies," to design, produce, market and sell products. With support from a National Science Foundation grant, the one-semester capstone project is utilized for integrating continuous quality improvement throughout the technical students' two-year programs. In their first three semesters, the electronics and engineering design students design, prototype, and redesign products for MIMIC. In their fourth semester, the technical students are teamed with business students to produce and sell the reengineered products. The students' courses meet at a common time so the student "companies" can meet, for training in such areas as group dynamics, and for communication experiences typical of the workplace. MIMIC not only exposes students to the world of industry within the confines of the classroom, it is a replicable, cost-effective model that can include industry partners and can be integrated into various programs and college settings.

Similar Projects at Other Institutions

Entrepreneurial team projects are relatively common in university engineering programs. They vary in focus, participants, and length, but none appear to exactly match the MIMIC model. Some projects emerge from programs encouraging entrepreneurship, like Pennsylvania State (Bilen *et al.*, 2005). Some projects, like the University of Maryland (Barbe, *et al.*, 2001), are a part of incubator-like environments where prospective entrepreneurs live together. Some universities facilitate start-up ventures: Florida Institute of Technology (Ports, *et al.*, 2005) and Stanford University (Stanford Technology Ventures Program, n.d.), for example. A high tech manufacturing facility is available for teams to produce a product, for example, at the University of Missouri-Columbia (Zayas-Castro, *et al.*, 2002). A business plan competition is the focus at the Massachusetts Institute of Technology (MIT $50k Entrepreneurship Competition, n.d.)

At some universities, the teams work with industry partners, i.e., at Lehigh University (Ochs, *et al.*, 2001) and Michigan Technological University (Raber and Moore, 2005). At some universities, multi-disciplinary project teams include MBA students, i.e., at University of Nevada-Reno (Wang and Kleppe, 2001) and University of Florida (Stanfill, *et al.*, 2004). Other projects include undergraduate business students, i.e., University of Missouri-Columbia (Zayas-Castro, *et al.*, 2002) and Lehigh University (Ochs, *et al.*, 2001). Some projects are capstones, i.e., at the University of Nevada-Reno (Wang and Kleppe, 2001). Other teams exist several years, i.e., at Rowan University (Engineering Clinics, n.d.) and Michigan Technological University (The Enterprise Program, n.d.).

At community colleges, technical team projects are also relatively common (Mott, 2002; Gordy and Ezzell, 2004), and agreements with universities allow some community college students to participate in projects at a university (Liou, *et al*, 2003). However, multi-disciplinary entrepreneurial projects, which include business students, are either rare or not well publicized.

Origin of the MIMIC Concept

In 1995, the engineering design instructor and a business instructor at Illinois Valley Community College developed a creative plan to provide their students with workplace experience. As a project in one of their courses, the instructors integrated their students into teams to develop, produce and sell a product. Shortly after MIMIC's successful debut, the project expanded. Electronics students joined the student companies, and product specifications were revised to require electronic components. Additionally, a MIMIC business course was developed as a capstone for students in Associate in Applied Science degree programs in marketing, accounting, management, computer systems and information systems.

MIMIC's Current Role

Today, with support from National Science Foundation Grant #0501885, the one-semester MIMIC project is being used as a catalyst to embed continuous quality improvement methodology (CQI) throughout the two-year electronics and engineering design curricula.

For the first ten years of MIMIC, the entire process was completed in one semester, including team assignments, product decisions and designs, training in teamwork and other skills, prototyping, production, marketing and sales. The one-semester time frame successfully provided teamwork, problem solving, entrepreneurship and communication experiences, but it limited the design experience of the technical students and the viability of the products. Expanding the program to introduce electronics and engineering design students to CQI in their first semester courses solves those problems. In the first semester of their two-year programs, students learn CQI principles and receive hands-on experience with reengineering in Computer Aided Drafting I, which is required in both electronics and engineering design. The students analyze previous MIMIC products and make recommendations for improvements. In their second and third semesters, technical students continue to study CQI, design products, build prototypes, analyze the prototypes, redesign, and so on. Just before the fourth semester, the instructors select the products for the MIMIC project from the redesigned products. The instructors evaluate the quality of the design, ease of production on campus, cost and marketability.

The fourth semester is the MIMIC project semester, when products are manufactured and sold. Students enrolled in the following courses participate:

- Design Projects, a capstone engineering design course,
- Motors and Controls II, a sophomore electronics course, and
- Integrated Business Operations, a capstone business course.

The courses are scheduled at a common time to allow for company meetings and training.

At the beginning of the MIMIC semester, the instructors assign students to companies and a product to each company. Enrollment determines the number of companies and number of students from each discipline assigned to each company. Typically, a company includes two engineering design students, two electronics students, and a mix of business students. Companies meet immediately for orientation and training and continue to meet at least once a week throughout the semester. Instructors from other disciplines are brought into company meetings or into the individual courses to teach workplace skills such as teamwork, goal setting, and problem solving, as consultants would be hired to provide training in a business or industry. Communication channels, including e-mail and an electronic discussion board, are established to allow students to conduct their company business realistically.

In their early meetings, the student teams decide how to produce and market their product and develop a product and corporate name. Students assume responsibility for a portion of the project based on their discipline, and they facilitate company meetings on a rotating basis.

The teams research and purchase materials and determine the selling price. A minimum of one week is devoted to producing the products with students in all of the disciplines participating. The number of units to be produced is set by the instructors. Marketing students design packaging and prepare the instructions for assembly and/or operation. Business students plan and promote an on-campus fair where the products are sold. All students are required to assist in the sale of their product. After the fair, accounting students prepare a cost analysis and make a recommendation on the commercial viability of the products.

MIMIC Products

Products created by student teams have included security devices, desktop water fountains, electronic games, lamps, and clocks. The flashing drink holder, Figure 1 and Figure 2 below, is a MIMIC product. Marketed under the name Kan Kuzzie, this drink holder incorporates fiber optics with a tri-color LED and a printed circuit board. The top, bottom and battery holder were produced in a rapid prototyping machine. This product was produced and sold from the original design; it has yet to undergo reengineering.
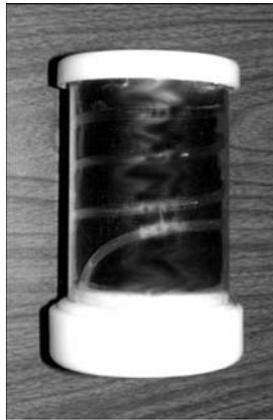
Figure 1: Flashing drink holder, exterior

Figure 2: Drink holder, interior

The strobe light, in Figures 3 and 4 below, illustrates how reengineering is improving product quality. Figure 3, on the left, shows the side and top view of the original product that was designed and sold a few years ago. Given the limited time the students had from concept to production, the original is relatively well designed. The original light also predates the students' access to rapid prototyping and mold making capability. Newer technology and reengineering allowed students to create the more commercially viable and professional product in Figure 4.

Figure 3: Strobe light original

Figure 4: Strobe light reengineered

The new design is also more effective. The original design concentrated light in one direction, upward from the box. The new design distributes light more evenly throughout a room because the entire upper section is made of clear plastic. The RC time constant in the new design was also altered to affect the time charge rates, affecting the flash rates.

Learning in the MIMIC Project

MIMIC is a learning-centered project, providing training and practice in leadership, teamwork, problem solving and critical thinking, in addition to requiring students to apply their technical skills. MIMIC also provides students with opportunities to learn about and experience:

- the entire process of manufacturing,
- technologies outside of their discipline,
- thinking and communication styles of other disciplines,
- scheduling and time management,
- oral and written communication modes appropriate to their discipline.

At every stage in the process, all team members participate in making company decisions, such as purchasing of components, pricing, producing, and selling the product. That participation helps them to understand how their role fits into the entire process.

Throughout their programs, technical students become experienced with technology they will utilize in the workplace; MIMIC exposes them to technology outside of their fields. For example, electronics and engineering design students become familiar with Excel while the business students are introduced to AutoCAD and rapid prototyping. Understanding different technologies helps them to work together productively.

The students also encounter diverse thinking and communication styles as they interact in their companies and, with the assistance of training in group dynamics and communication, they interact more productively. The need for training to improve interaction, especially between technical students and business students, is illustrated in the following feedback from students:

- An electronics student: "We can't get money out of the accountants to buy parts."
- An accounting student: "The engineering and electronics students won't give me any numbers."
- An engineering design student: "Marketing students said we'd never be able to sell it. The accountants said our idea was no good – too complicated."

Obviously, these issues are typical of the workplace.

In their companies, students receive training in goal setting and time management. Their hands-on teamwork makes the students aware of deadline responsibilities in a way that individual classroom assignments do not. In exit interviews, students routinely advise future MIMIC participants not to relax even if they are on schedule.

A number of communication exercises are integrated into MIMIC. In addition to small group communication required for student companies to function successfully, the students participate in communication situations that would be required of them on the job. All students give oral presentations in a 120-seat, multi-screen, electronic lecture hall to members of the faculty and administration in addition to the student teams. Presentations are scheduled throughout the semester with students from each discipline explaining their portions of the project; engineering design students, for example, defend their product designs early in the semester, and electronics students explain electronic components before production begins. The types of written materials produced by the students are also discipline-specific; technical students detail their design and component choices in formal, technical reports.

Assessment in the MIMIC Project

The MIMIC project, students, and products undergo extensive evaluation. MIMIC instructors, consulting instructors, students, product buyers and business/industry leaders evaluate plans, designs, prototypes, products, written materials, oral presentations, teamwork, and student participation. A full assessment of the four-semester focus will not be possible until the first students complete their two-year programs, but past assessments of MIMIC have been very positive. Business and industry leaders have been supportive because MIMIC gives students hands-on experience dealing with workplace problems. Student feedback has also been very positive. Typically, students are skeptical about the benefits of the project as they begin and frustrated during the project. By the end, they recognize the value of the experience in preparing them for the world of work. An advisory committee of business and industry representatives has been formed to provide guidance as the technical programs incorporate reengineering. The committee also provides an ongoing, formal structure for feedback on MIMIC itself.

Cost for a MIMIC-like Project

MIMIC has been very cost effective. Although a National Science Foundation grant is currently providing some funding, MIMIC has been offered for ten years on a budget of approximately $3,000 a year:

- $1,200 for the three instructors ($400 stipend each),
- $1,000 for product supplies, divided equally among the student companies,
- Under $1,000 for stipends to instructors for training in teamwork and other workplace skills.

Since it began, MIMIC has been sponsored by the college's Tech Prep team, with funding provided through Carl D. Perkins federal legislation. Students have helped to control costs by locating low-cost supplies and soliciting donations from lumberyards and hardware suppliers. Product sales have covered some additional expenses.

A similar project would require start-up funding or industry sponsorship but could be nearly, if not entirely, self supporting through product sales.

Adaptability of the MIMIC Model

MIMIC is an adaptable model for integrating students from diverse disciplines, as illustrated by a spin-off project at IVCC. Students in engineering design, electronics, theatre, English, art, graphic design and business designed and built a portable puppet theatre and puppets; developed and administered a budget; and wrote, promoted and produced a play. The project required the technical students to work with theatre students to learn about theatre materials and stage lighting effects and zones. Integrating technical students with liberal arts students provided even more teamwork and communication challenges than the original MIMIC project. As the theatre instructor said, "Design and electronics students approach a project differently compared to theatre students."

Integrating teams of students from diverse areas to produce products can also be accomplished at various educational levels and can involve industry partners. The MIMIC model can be adapted to various college settings, including university programs, by adjusting the complexity of the products to match student backgrounds and expectations/standards of the instructor, course or program. A number of universities offer projects that incorporate aspects of the MIMIC model, as the literature review listed previously illustrates.

At IVCC, MIMIC has truly made industry meaningful, and the MIMIC project can be used as a blueprint for other universities to make industry meaningful to their students.

References

Barbe, D.F., Baum, J.R. and Thornton, K.S. (2001). Campus Entrepreneurship Opportunities, Proceedings of the 2001 American Society for Engineering Education Annual Conference & Exposition. Session 3454.

Bilen, S. G., et al. (2005). Developing and Assessing Students' Entrepreneurial Skills and Mind-Set, Journal of Engineering Education, April 2005, pp. 233 – 243.

Engineering Clinics. (n.d.) Retrieved Jan. 20, 2006, from Rowan University Web site: http://www.rowan.edu/colleges/engineering/clinics

The Enterprise Program. (n.d.) Retrieved Jan. 20, 2006, from Michigan Technological University Web site: http://www.enterprise.mtu.edu

Gordy, P. and Ezzell, S. (2004) Energizing Your Engineering Program Through Competitions and Team-Based Projects, Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition.

Liou, F., et al. (2003). An Integrated and Distributed Environment for a Manufacturing Capstone Course, Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition. Session 2563.

MIT $50k Entrepreneurship Competition. (n.d.) Retrieved Feb. 25, 2006 from Massachusetts Institute of Technology Web site: http://www.mit50k.net

Mott, R. L. (2002). Use of Activity-Based Learning Across the Curricula In Mechanical, Manufacturing, and Industrial Engineering Technologies, Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition. Session 3549.

Ochs, J.B., Watkins, T.A., and Boothe, B.W. (2001). Creating a Truly Multidisciplinary Entrepreneurial Educational Environment, Journal of Engineering Education, Oct. 2001, pp. 577 – 583.

Ports, K., et al. (2005). Senior Design Project Commercialization and Entrepreneurship, Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition.

Raber, M., and Moore, M. (2005). The Enterprise Program at Michigan Technological University: A Professional Development Curriculum in Action, Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition.

Stanfill, R. K., et al. (2004). Integrating Entrepreneurial Projects into a Successful Multidisciplinary Capstone Design Program at the University of Florida, Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition. Session 1693.

Stanford Technology Ventures Program. (n.d.) Retrieved Feb. 25, 2006 from Stanford University Web site: http://www. stanford.edu/ group/stvp

Wang, E. L., and Kleppe, J.A. (2001). Teaching Invention, Innovation, and Entrepreneurship in Engineering, Journal of Engineering Education, Oct. 2001, pp. 565-570.

Zayas-Castro, J.L., et al. (2002). EMILE: A Concerted Tech-Based Entrepreneurship Effort Between Engineering and Business, Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition. Session 3454.