2006-585: A MULTI-DISCIPLINARY ENTREPRENEURIAL PROJECT FOR TEACHING REENGINEERING

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A Multi-Disciplinary Entrepreneurial Project for Teaching Reengineering

An entrepreneurial project at Illinois Valley Community College immerses engineering design and electronics students in reengineering and entrepreneurship over the course of their two-year technical programs. The project also teams the technical students with business students, simulating an industrial company structure.

Entitled Making Industry Meaningful In College (MIMIC), the project was pioneered at IVCC as a one-semester multi-disciplinary project with students from engineering design and business teamed into "companies" to select, design, prototype, manufacture, market and sell products. Later, electronics students were added, and MIMIC became a capstone for students in several business fields. Now, with the support of a National Science Foundation Grant[1], elements of the entrepreneurial project are being incorporated throughout the technical students' two-year programs.

Engineering design and electronics students are being introduced to continuous quality improvement in their first, introductory courses, and they are designing and reengineering products throughout their first three semesters. In their fourth semester, the students are teamed with business students into MIMIC "companies" to manufacture, market and sell the reengineered products. Workplace skills, including teamwork, problem solving and communication, are emphasized especially during the entrepreneurial MIMIC semester.

Making Industry Meaningful In College not only exposes students to the world of industry within the confines of the classroom, it provides a common thread throughout the technical programs. MIMIC is a replicable, cost-effective model that can be adapted to a varying number of semesters and integrated into a variety of technical programs and college settings.

Entrepreneurial projects at other institutions

Entrepreneurial team projects are an increasingly popular component of university engineering programs. Providing students with realistic experiences is a common goal, but the projects vary in their purposes and outcomes, organization, participants, and length.

Some projects emerge from programs that encourage engineering students to become entrepreneurs, for example, Pennsylvania State[2]. Others, like the University of Maryland[3], are a part of incubator-like environments where prospective entrepreneurs live and study together. Some universities take the process a step further by facilitating start-up ventures: Florida Institute of Technology[4] and Stanford University[5].

For some projects, a business plan is the significant outcome, and a business plan competition is the focal point for entrepreneurial efforts; the Massachusetts Institute of Technology's $50K Competition[6] is among the best known. In other programs, production of a prototype and/or development of a process receive more emphasis. To facilitate production, on a few campuses a high tech manufacturing facility is available for the student teams; the

Entrepreneurship-Manufacturing Innovation Lab Experience at the University of Missouri-Columbia[7] and the Learning Factory at Pennsylvania State University, University of Washington and University of Puerto Rico[8] are examples. At some universities, the student teams work with industry partners: Lehigh University[9] and Michigan Technological University[10], for example.

At some universities, multi-disciplinary project teams are primarily made up of engineering students but may include MBA students: University of Nevada-Reno[11] and University of Florida[12], for example. Other projects include undergraduate business and even liberal arts students: University of Missouri-Columbia[7] and Lehigh University[9], for example. In yet another model, students from multiple universities are teamed; the NSF Gateway Coalition creates student teams from universities in four states[13].

Some team projects are capstones: at the University of Nevada-Reno[11], for example. Other teams are formed in the students' freshman or sophomore years and continue throughout their undergraduate programs. The teams in the Engineering Clinics at Rowan University[14] exist for four years; those in the Enterprise Program at Michigan Technological University[15] and the Student Engineering Enterprises at Lawrence Technological University[16] exist for three.

At community colleges, engineering team projects are relative common: Sinclair Community College[17], and Tidewater Community College[18], for example. Cooperative agreements with universities also allow some community college students to participate in product-development projects at a university; St Louis Community College at Florissant Valley has such an agreement with the University of Missouri-Rolla[19]. However, multi-disciplinary entrepreneurial projects at community colleges, especially those which include business students, are either rare or not well publicized.

The evolution of the IVCC project

The evolution of MIMIC at Illinois Valley Community College illustrates that a multi-disciplinary entrepreneurial project can be developed through a fairly simple start-up process and the development can be in stages. MIMIC was created 11 years ago when the engineering design instructor and an accounting instructor decided to team their students into "companies" simulating an industrial environment. As a project in one of their courses, the students would design, produce and sell products. To allow student teams to meet, the instructors arranged for their classes to meet at a common time during the spring semester. The instructors also recognized a need for special training for the teams, in such areas as team building and communication. IVCC instructors with specialties in those areas were scheduled into team meetings to teach those skills, just as consultants would be hired to provide training in a business/industrial setting. Since the project was designed to prepare students for the world of work and it integrated academic and technical course material, it qualified for Carl D. Perkins grant funding.

At the conclusion of its first year, MIMIC received an award for innovative integrated curriculum from the Illinois State Board of Education.

Within a few years, electronics students joined the student teams, and product specifications were rewritten to require electronic components. Students in other courses and fields have also played a role in the project; for example, graphic design students have developed company logos and technical writing students have written product instructions.

The business side of MIMIC has also expanded. Initially, students enrolled in an accounting class handled all business aspects of the student companies, including marketing, information processing, accounting and organization of a fair where products were sold. To make the experience more realistic and practical, a MIMIC business course was developed as a capstone for Associate in Applied Science degree programs in marketing, accounting, management, computer systems and information systems. Student companies now include a mix of students from the business fields.

Since its inception, the MIMIC project has successfully provided students with hands-on experiences with entrepreneurship, teamwork and communication. MIMIC has also addressed a special problem the technical programs face because of the college's location. Illinois Valley Community College is centrally located in a 2,200 square mile district in north central Illinois. In this rural, primarily agricultural district, the largest community has a population of 18,000. As a result of the limited industrial base in the district, internships and industry partnerships can be problematic. Technical jobs, however, are readily available just outside of the district: Chicago, Peoria and Rockford are all within 60 to 100 miles of the campus. MIMIC has provided a solution to the dilemma faced by the college's technical programs since it allows students to experience a simulated industrial workplace.

In the first ten years of the project, however, the entire process was completed in one semester, including:

- Assigning students to multidisciplinary "companies,"
- Providing training in project management, teamwork, problem solving, critical thinking and communication skills,
- Choosing, designing, prototyping, manufacturing, marketing and selling products.

The limited time frame did not allow students to absorb the training, design viable products, and experience continuous quality improvement methodology. Expanding the program for the engineering and electronics students solved those problems.

The organization and scheduling of the project today

Today, reengineering and continuous quality improvement are being embedded throughout the two-year engineering design and electronics curricula with the entrepreneurial MIMIC project serving not only as a capstone project but also as the impetus for the reengineering. Students are immersed in workplace methodology throughout their programs, and they have the time to design and reengineer viable products for the student teams to produce and sell.

Students are introduced to CQI principles in the beginning CAD course, Computer Aided Drafting I, which is required of both engineering design and electronics students. The students break down and analyze products built by student teams in previous semesters and make

recommendations for improvements on those products. In their second and third semester courses, students continue to study CQI principles, and they continue to design, prototype, redesign and prototype products. In the third semester, the engineering design students also receive training in project management.

In semester four, students participate in MIMIC. Just before the semester begins, the instructors evaluate the redesigned products, not only for the quality of the redesign, but also for the cost, ease of production on campus, and marketability. With more products redesigned than needed for the student companies, some products are not selected for production.

Students enrolled in the following courses participate in MIMIC:

- Design Projects, a capstone engineering design course which enables students to use their skills to design products for production and act as project managers,
- Digital Microprocessor, an electronics course which focuses on logic gates and design procedures, TTL circuits and CMOS technology,
- Integrated Business Operations, a capstone business course which offers credit for the business side of the student companies.

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

The semester begins with the instructors assigning students into their companies and assigning each company to a product. Enrollment determines the number of companies and how many students from each discipline are in each; typically a company includes two engineering design students, two electronics students, and a mix of students from the various business fields. Where possible, when a student in one of the companies has worked on a redesign of a selected product, that product is assigned to the student's company.

Companies meet immediately for orientation and for training. Instructors from other disciplines are brought into the company meetings or into the individual courses, as consultants would be in a business or industry setting, to teach workplace skills such as teamwork, goal setting, problem solving, critical thinking and communication skills. While certain training sessions are routinely provided, others are added based on the needs of the students and student companies that semester.

Communication channels, including e-mail and an electronic discussion board, are established to allow students to conduct their company business realistically; students must prepare agendas, take and disseminate notes of meetings, for example.

During the weekly meetings that follow, companies decide on a product name and corporate name and training in various workplace skills continues. While the engineering design students act as project managers, students assume responsibility for a portion of the project based on their discipline: marketing students survey potential buyers to gauge product and pricing preferences and research any competition, accounting students start on production budgets, business students plan the on-campus fair where the products will be sold. Students also assume responsibility for facilitating company meetings on a rotating basis.

The student teams research and purchase materials and determine the final selling price. A minimum of one week is devoted to producing the products with the students in all of the disciplines required to participate. The number of units to be produced is set by the instructors. The student teams work with the manufacturing instructor and students, as needed, to produce their products. While it would be preferable to include manufacturing students in the MIMIC companies, enrollment and scheduling problems have prevented manufacturing students from participating fully in the project. Since manufacturing enrollments are small and most manufacturing students are employed full-time, their courses are scheduled in the evening, making it impossible for those students to meet with the MIMIC companies on a regular basis.

Marketing students design packaging, and prepare the written instructions for assembly and/or operation of the products by working with students in a technical writing class. Business students are in charge of scheduling, planning, picking a theme, promoting and setting up an end-of-semester MIMIC Fair where the products are sold. All of the students assist in the sale of their company's product at that on-campus event. The final work on the project is completed by accounting students who prepare a cost analysis of the sales at the fair, which culminates in a recommendation on the commercial viability of each product. The entrepreneurial component wraps up with a celebration dinner for all participants with awards and certificates presented to the students.

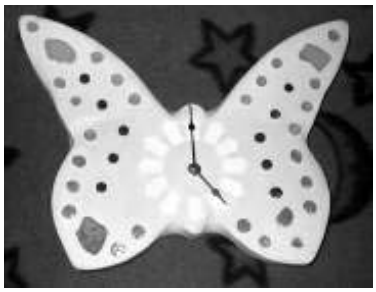
A student guidebook listing expectations and requirements and additional information about the project is available on the MIMIC web site.[20]

Products previously created by student companies

Over the last ten years, when student teams had one semester to select, design, prototype, produce and sell their products, typical products included security devices, desktop water fountains, electronic games, lamps, clocks and lighted picture frames.

At the beginning of the semester, the teams decided what they would produce, subject to approval by the MIMIC instructors. Based on a proposal the student teams submitted online, the engineering and electronics instructors evaluated the feasibility, design intent, functions, specifications and capability for manufacturing and assembly on campus. The business instructor evaluated marketability and cost factors. Approval from all three instructors was required.

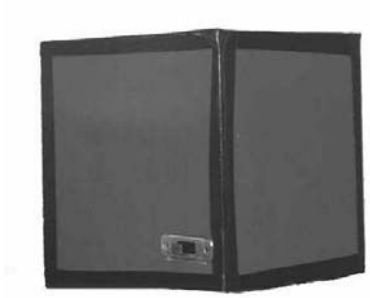
The lighthouse, at left, was a popular product at a MIMIC Fair. Intended as a yard ornament, the lighthouse is 18 inches tall, incorporates a solar-powered light, and is constructed of clay pots.



The butterfly-shaped clock, at left, was one of several shapes and sizes produced by a student company. Each of the battery-operated clocks is decorated with chips of stained glass held in place by a grout mold. The mold shapes were designed by the CAD students on that team.

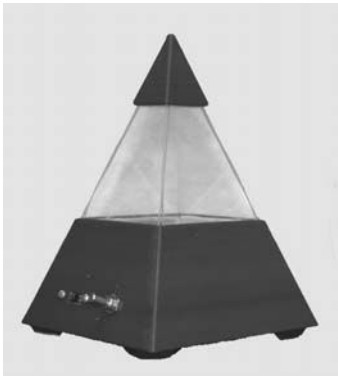
Student products being reengineered

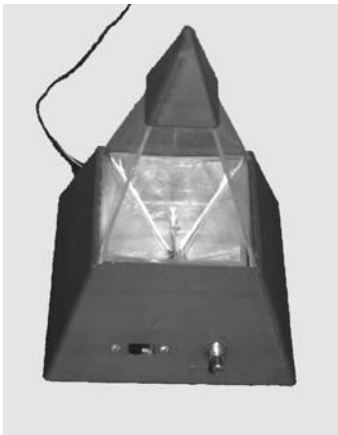
Products previously manufactured and sold by student teams are now being reengineered, not only to incorporate newer technology but also to improve the original design, functions, components, cost and ease of production. More products are reengineered than needed for the student companies, allowing the instructors to select the best of the redesigned products for manufacture and sale. More importantly, students are immersed in the continuous quality improvement process throughout their technical programs. The strobe light (below) illustrates how reengineering is improving the quality of the products.



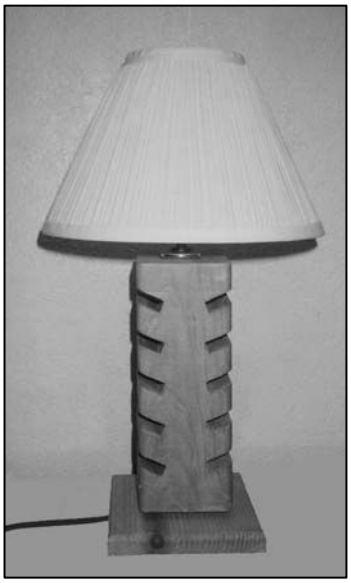
The strobe light on the left is the original product that was designed, produced and sold by a student team several years ago. The light on the right is the reengineered product.

The original went from concept to sales in one semester. The original is well designed for its time, given the limited time frame, and the fact that the product predates the students' access to rapid prototyping and mold making capability. For aesthetic purposes, the students taped over the glue that held the plastic box together. Newer technology and reengineering allowed students to create the more commercially viable and professional product on the right.

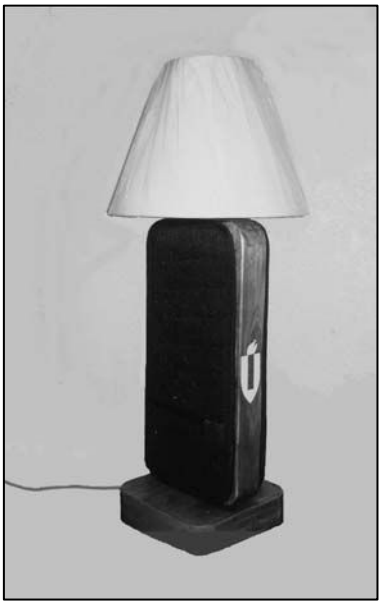




The new design is also more effective. The original design concentrated light in one direction, upward from the box. The new design distributes light more evenly throughout a room because the upper section is made of clear plastic. In the electronic features, the RC time constant in the new design was altered to affect the time charge rates, which affects the flash rates. The new design includes a straight xenon tube, replacing a u-shaped one in the original design, and the circuit board was repositioned to accommodate the other design changes.



The lamp, at left and right, is another product being reengineered. Intended to provide storage for CDs in the base, the original lamp is on the left and the first redesign on the right. In the original, CDs are to be stored in slots designed in the wooden base. The reengineered lamp utilizes a canvas and mesh CD holder designed for use on an automobile visor; the CD holder is attached to the wooden base with Velcro.



The original product has a much wider base and stores only 10 CDs; the redesigned lamp, with a much slimmer profile, stores 20 CDs. The redesigned product also incorporates a graphic, of the college logo on this prototype. The CD lamp is still undergoing reengineering to improve its stability and proportions. Access to the CD slots near the shade is also problematic; and the switch, which is currently in-line, is being analyzed.

Integration of business students into the project

The business students who participate in MIMIC, the entrepreneurial component, are enrolled in a capstone course, Integrated Business Operations, required in their Associate in Applied Science degree programs. They are from a variety of career fields, including marketing, accounting, management, computer systems and information systems, which allows the makeup of the "companies" to be representative of an industry. Integrating students from various disciplines not only fulfills the technical needs of the student teams but also provides valuable interaction and communication opportunities. Acting on the advice of the advisory committees for their career programs and utilizing a list of essential workplace skills[21] endorsed by the area Tech Prep consortium, the instructors who organize the project make the development of teamwork and communication skills a major focus. In their technical courses, the engineering and electronics students do work in teams and communicate with other technical students. In their companies, however, the students experience how people in other disciplines think and work, and they are encouraged and trained to adapt and communicate

more effectively with people outside of their disciplines. Ten years of experience with the original MIMIC project continued to reinforce the need for such training and practice.

Communication exercises in the project

A number of communication exercises are integrated into the entrepreneurial, MIMIC semester. In addition to the small group communication skills required for the student companies to function successfully, the students complete other types of communication exercises that would be required of them on the job. All of the students give oral presentations in a 120-seat, multi-screen, electronic lecture hall. In addition to the student teams, the audience includes members of the faculty and administration. The presentations are scheduled throughout the semester with students from each discipline explaining their portions of the project. Engineering students, for example, defend the product designs early in the semester; and accounting students defend their recommendations at the end of the semester.

The types of written materials produced by the students are determined by their discipline. Engineering students detail the product designs in formal, technical reports. Marketing students create sales slogans, advertising materials and product descriptions. Business students prepare notes of company meetings and send invitations and thank you messages to faculty who serve as consultants.

Evaluation and assessment of the project

Since the one-semester MIMIC project has just been expanded to a four-semester program, a full assessment of the impact of the program will not be possible until the first group of freshmen have completed their technical programs. However, an examination of the first redesigned products (see examples above) is a clear indication that product quality and viability has improved. An advisory committee of business and industry leaders has been created to provide guidance on an ongoing basis as MIMIC and the technical programs evolve; the committee members will be evaluating the program, products and students' preparation for the world of work. In addition to ongoing feedback from the advisory committee, the MIMIC project and technical students are being evaluated from a number of perspectives.

In the semesters before the entrepreneurial component:

- Instructors evaluate original product plans, designs, drawings and prototypes
- Instructors evaluate student analyses of products and recommendations for redesign,
- Instructors evaluate redesigns and working drawings,
- Instructors evaluate the final drawing package.
- Instructors evaluate models and prototypes.

During the entrepreneurial, MIMIC semester:

- Instructors evaluate teamwork and communication skills.
- Instructors evaluate marketing surveys, promotional plans and materials, accounting reports and financial plans.

- Consulting instructors assist in evaluations or oral reports, written reports, e-mail and memos.
- Potential buyers evaluate products.
- Accounting students evaluate the commercial viability of products, based on product sales and a cost analysis.

At the conclusion of and following the entrepreneurial, MIMIC semester:

- Students provide feedback on their teams, on the training provided by the consulting instructors and on the entrepreneurial project.
- Technical students provide feedback about the four-semester program.
- Business and industry leaders provide feedback on the products, program and graduates.

Since the MIMIC project first began, business and industry leaders have been overwhelmingly supportive because MIMIC prepares students for the workplace by giving them hands-on experience dealing with workplace problems. Student feedback has also been very positive, with students acknowledging their initial reluctance and/or resistance to the project and their frustration during the project, but recognizing the value of the experience in preparing them for the world of work.

Costs to establish a similar project

A MIMIC-like project can be established with minimal funding, as the experience at Illinois Valley Community College illustrates. For spring 2005, the MIMIC budget was approximately $3,000:

- $1,000 for product supplies.
- $1,200 for the three instructors ($400 stipend each)
- Under $1,000 for stipends to other IVCC instructors for providing training in teamwork and other workplace skills, at the rate of $75 for a new one-session exercise and $50 for a repeated one-session exercise.

For product supplies, each student company is allocated a budget determined by the number of companies formed that semester. MIMIC instructors have controlled project costs by determining the number of teams, the requirements the student-designed products must meet, and the number of units each team must produce. Typically, a total of 40 to 60 students participate in MIMIC, resulting in four to six student companies.

Since its inception, the MIMIC project has been sponsored by the college's Tech Prep team, with funding provided through Carl D. Perkins federal legislation. The student teams have been enterprising in locating low-cost supplies and successful in soliciting donations of supplies from hardware suppliers and lumberyards. Product sales have covered some additional expenses for supplies and end-of-project recognition for the students. Currently, a grant from the National Science Foundation is providing funds for some of the entrepreneurial project including product supplies, a stipend for the manufacturing instructor and some stipends to IVCC instructors for providing training in teamwork and other workplace skills. But MIMIC began and has been offered for ten years with a budget of $3,000 or less each year.

While a similar entrepreneurial project would require start-up funding for product supplies and stipends for participating instructors, a project could become self-supporting through product sales combined with careful planning and well-researched purchasing. In geographic areas with an industrial base, development of industry partnerships could minimize the funding required.

Adaptability of the project model

Illinois Valley Community College's experience with MIMIC proves that an entrepreneurial project can begin with instructors organizing their students to work together within existing courses. And while MIMIC is a capstone project for four-semester technical programs at a community college, the concept is adaptable to a varying number of semesters in a variety of college settings. IVCC's early experience proves that the project can be successful in one semester. To incorporate reengineering, however, a minimum of two semesters is needed.

The program can be adapted to various college settings, including university programs, by adjusting the complexity of the products to match student backgrounds and instructor/course/program expectations. Programs that incorporate aspects of MIMIC are offered at a number of universities, as the literature review (presented above) illustrates.

An offshoot of the MIMIC model pioneered at IVCC in 2002 illustrates the adaptability of the model to different entrepreneurial settings. Four years ago, MIMIC organizers worked with theater, art and English instructors on a project entitled Give Us a Hand Puppet Production. Students designed and built a portable puppet theater with a lighting system, designed and constructed puppets, wrote a script, auditioned for parts, developed and managed a budget, created marketing materials, marketed and presented a production. Over the two semesters of the project, engineering design and electronics students worked with theater students to learn about theater materials, design elements, and stage lighting effects and zones. Electronics students consulted with engineering design students to ensure the lighting system fit in the theater. As materials were being selected, technology and theater students consulted with accounting students about expenditures and learned the impact of finances. Theater students also learned how engineering and electronics students approach a project. This theater project illustrates that the adaptability of the MIMIC model is limited only by the commitment and imagination of organizers and support of college administrators.

By making the connection from college to the workplace, MIMIC has demonstrated that education can be more than an imitation of life. MIMIC has proven to be an effective entrepreneurial program for integrating technical and business students and for sharpening the students' technical, teamwork, critical thinking and communication skills. For community colleges located in geographic areas where internships and industry partnerships are problematic, MIMIC can be a reasonable alternative by providing simulated world of work experience on campus. MIMIC is a replicable, cost-effective model that can be adapted to a varying number of semesters and integrated into a variety of technical programs and college settings.

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