

## **AC 2007-1016: IMPACT: INNOVATION THROUGH MULTIDISCIPLINARY PROJECTS AND COLLABORATIVE TEAMS**

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# IMPACT: Innovation through Multidisciplinary Projects and Collaborative Teams

## Abstract

IMPACT (Innovation through Multidisciplinary Projects and Collaborative Teams) is a collaborative effort between faculty, students and industry representing engineering, business and other colleges. The goal of IMPACT is to support multidisciplinary design experiences for engineering, business and other students (for example: graphic design, nursing, and education.) As a result, IMPACT promotes a culture of entrepreneurship and innovation throughout the university and region. IMPACT's year-long multidisciplinary design projects provide opportunities for students to experience the entire research, development and marketing process. IMPACT courses provide vertical integration by including freshman through senior students in the product design process as well as horizontal integration across various disciplines and majors. IMPACT students can earn technical elective credit as well as capstone design credit. To date, IMPACT teams have included a variety of junior and senior engineers (mechanical, biomedical, electrical) along with finance, marketing and MBA students.

## Introduction and Background

As of January 2007, IMPACT is in its first year of full-scale operation. The IMPACT program began during the 2005-06 academic year and received two years of NSF funding beginning in the 2006-07 academic year. IMPACT began as an adaptation of Purdue's highly successful EPICS (Engineering Projects in Community Service). The EPICS program was initiated in the fall of 1995 with NSF funding and has been hugely successful.<sup>1</sup> In surveys of 1078 students who have participated in the program, 84% of the students rated the program as an overall "A" or "B" on a letter grade scale. The students rated such areas as how much the program helped their communication skills, ability to work on a team and understanding the design process, along with several other categories. The program has won several awards including the 1997 ASEE Chester F. Carlson award for Innovation in Engineering Education. Also, Iowa State, Notre Dame, Georgia Tech, Case Western, Penn State and others have all implemented an EPICS program.

Several recent developments at Louisiana Tech University have laid the groundwork for IMPACT and other collaborative efforts. In 1996, the science and engineering departments of Louisiana Tech were merged to form a new College of Engineering and Science (COES), and an innovative administration structure was employed to facilitate strong interdisciplinary collaborations for both research and education.<sup>2,3</sup> This structure has allowed for the development of innovative interdisciplinary undergraduate programs such as our Integrated Curricula and multidisciplinary programs such as our Center for Entrepreneurship and Information Technology (CEnIT). For purposes of this paper, interdisciplinary is defined as collaboration within a specific field such as engineering, while multidisciplinary refers to collaborations between diverse fields such as engineering and business.

The COES at Louisiana Tech established an Integrated Freshman and Sophomore Engineering Curriculum (IEC) in 1997.<sup>4-6</sup> The success of the program prompted the follow-on Integrated Science Curriculum, which includes math, chemistry, physics, computer science, biology, and math/science education. Both of these programs have helped create a truly interdisciplinary culture among our undergraduate students. Team skills are emphasized throughout the entire undergraduate program beginning in the first quarter. The IEC is structured such that engineering, math, chemistry, and physics courses are all interconnected, and students have significant design experiences in both the freshman and sophomore years. On the other hand, while the junior and senior engineering courses provide a solid background in each discipline specific area, there is less interdisciplinary focus, and almost no multidisciplinary focus at this level. The IMPaCT program was created specifically to address this lack of inter- and multidisciplinary work by creating an alternate track for students who wish to pursue a truly multidisciplinary curriculum with an emphasis on entrepreneurship.

### IMPaCT Overview

The IMPaCT program provides opportunities for students from all over campus to work together to solve problems. Students can elect to enroll in IMPaCT from two different perspectives – Innovative Product Design (which awards elective credit) or Senior Capstone Design (which awards senior design credit to senior engineers). An IMPaCT project lasts for at least one academic year, some projects may span multiple years, although it is not necessary for a student receiving elective credit to enroll for the entire year. Over the course of the year, student teams take a project from idea to prototype to business plan. IMPaCT teams consist of engineers, business students and other majors. Key features of the IMPaCT program include:

- Multidisciplinary teams of students working on long-term projects.
- Vertical integration of student teams to include all undergraduate levels with senior business and engineering students serving as the team leaders.
- Horizontal integration of student teams to provide students from all disciplines the opportunity to participate in IMPaCT.
- Academic credit for participation in IMPaCT projects.
- Project advisor(s) for each team with internal and external mentors
- Lecture series covering creative design, project management, business planning, and other skills necessary for well-rounded product development experience.
- Individual skill modules dedicated to just-in-time delivery of specific product development topics (rapid prototyping, fabrication techniques, etc...)
- Product development over the course of one academic year.
- Creation of a business plan for the newly developed product.

## Multidisciplinary Teams

One of the central themes of IMPaCT is its multidisciplinary nature. IMPaCT creates an environment in which students from various backgrounds come together to work as a team to solve problems. No longer do engineering students simply design a product without considering the financial viability of their device or its aesthetic form. Also, business students get experience working on real world projects and are involved in the entire design cycle. Other students who have interest in product development can also get involved; perhaps graphic artists want to try their hands at product design. One key aspect of IMPaCT is providing situations where students learn to communicate and work with people outside of their college discipline.

## Vertical Integration

The structure of IMPaCT allows students from freshman level up to graduate students to participate in the process. There is a core team of senior engineers who are working on an IMPaCT project for the entire year, earning senior design credit hours (ENGR 401) required to graduate. In addition to this core group, other students can join the team for one, two or three quarters and earn elective credit hours (ENTR 430). Vertical integration also creates the opportunity for multi-year projects. A student can take the IMPaCT series of courses for one year as technical elective credit and the next year can earn senior design credit working on a continuation or spin-off of the same project. Figure 1 graphically shows how students from freshman to seniors can be involved in the IMPaCT program.

## Horizontal Integration

Possibly even more valuable than vertical integration is the horizontal integration that IMPaCT fosters. Teams consist of a variety of engineering disciplines such as mechanical, electrical and biomedical, but the integration does not stop there. Students from a variety of majors outside of engineering work together to solve a common problem; each bringing their specialized training to the team effort. Business students provide an economic point of view that engineering students don't always think about. Engineering students provide technical know-how that business students may not have. Other students such as graphic designers bring form to the function, political science students bring social relevance, nursing students bring a passion for serving, - each student brings their own experiences and knowledge to form a team that can function with a much broader vision than otherwise possible. Figure 1 graphically shows how students from engineering, business and other majors can be involved in the IMPaCT program.

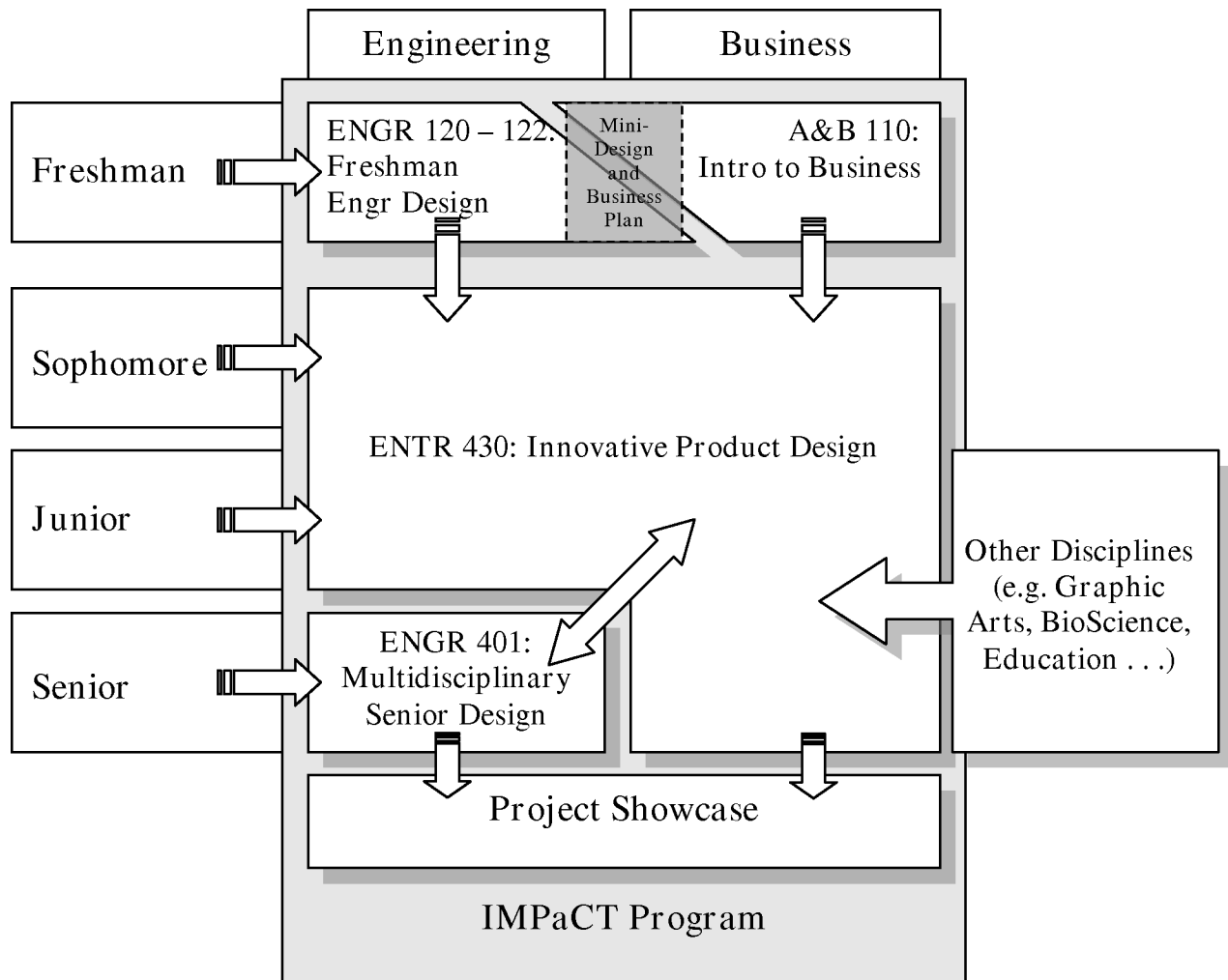


Figure 1. Vertical and horizontal integration of students in the IMPaCT program.

### Academic Credit

As previously mentioned, there are two types of credit hours that can be awarded for IMPaCT courses. Students can either receive engineering senior design credit (ENGR 401) or elective credit (ENTR 430). Only engineering students who are in their last year of study can earn senior design credit, all others will earn elective credit. IMPaCT is a year-long course that senior engineering students enroll in for three quarters. Other students may enroll in one or more quarters as they see fit, earning one credit hour per quarter. There are also several corollary courses that support IMPaCT projects and teams offered throughout the year. Students can enroll in these courses and earn credit hours as well. These support courses include business plan writing, innovative venture research and innovative product design. These courses and their relation to IMPaCT will be discussed in more detail in the section entitled Lecture Series.

### Project Advisors

Each IMPaCT team has one or more advisors/mentors to aid in their project. These advisors may be faculty members, industry experts, graduate students, or some combination of these three. The

teams meet with their advisors on a regular basis and will often treat the advisor as “the customer.” The frequency of team-advisor meetings are determined by the team and advisor, but average at least one contact per week. These contacts may be face-to-face, conference calls, web meeting, or written progress reports. The advisors also lend technical advice to the teams when needed.

### Lecture Series

The IMPaCT program is foremost a teaching program and student learning is the main goal. Not only do the students learn by doing, but they also attend a weekly lecture series. This lecture series consists of traditional lecture, multi-media presentations, active learning exercises, and team building components. There are also several assignments such as progress reports, presentations, and exams each quarter. The list of lecture topics and assignments for the 2006-07 academic year can be seen in Tables 1 – 3.

The topics are divided into two broad categories: technical topics and business topics. The technical topics are taught by an engineering faculty member while the business topics are taught by a business faculty member. Guest lecturers are also brought in to discuss various other topics of interest. For instance an accomplished entrepreneur may be brought in to share their experiences in starting their own business. The weekly IMPaCT class time is scheduled for three hours in the afternoon. The lecture topic normally lasts one hour with the remaining time devoted to teamwork and progress reports.

The Fall quarter focuses on team-building, brainstorming and gathering the background information necessary for the product design. During this quarter, teams complete the University challenge course. This course is a low-ropes course designed to combine physical activity and problem solving to encourage team members to learn how to work together. The teams also are taught good brainstorming habits and how to manage and plan their team work. The teams develop several concepts and create a product design specification for their product. The teams also determine their plan of action for the year. The primary deliverables for this quarter are the product design specification and product concepts. The class schedule for the Fall quarter can be seen in Table 1.

Table 1. Fall quarter IMPaCT class schedule.

Class	Topic
1	Introduction to the syllabus Video: The Deep Dive (ABC Nightline, 1999)
2	Class meets at the Challenge Course
3	What’s The Idea? – Develop a product idea from pictures and words. Defining and Solving Design Problems.
4	Videos on Lead Users The “IDEO Process” Formulating a Design Problem.
5	“Brainstorming” Concept Design

6	Preparing a PDS (Product Design Specification)
7	Principles of Universal Design Project Planning
8	Exam #1
9	The parts of a business plan
10	PDS Presentation

The Winter quarter focuses more on prototype development and gets deeper into their business planning. Teams learn a variety of techniques for prototyping (from sketching to spatial mock-ups to state-of-the-art rapid prototyping.) Business topics are also more prominent this quarter with topics such as marketing, value propositions, and determining market size. The main deliverables for the Winter quarter are a functional prototype and a business plan draft. The class schedule for the Winter quarter can be seen in Table 2.

Table 2. Winter quarter IMPaCT class schedule.

Class	Topic
1	Video: The Launch: A Product is Born Building and Testing Prototypes
2	Intellectual Property
3	First Prototype Presentations
4	Design for Manufacture -selecting materials -manufacturing processes -safety, tolerances . . .
5	Team presentations on Marketing Simplified
6	Lecture on estimating Market Size and Value Propositions Introduction to Codes and Standards
7	Team presentations on Customer, market size and Value Propositions Parametric Design
8	Team Presentations: Current Status of Prototype and Business Plans
9	Exam 2 Preparing a Testing and Evaluation Plan
10	Presentation of Final Prototypes

The Spring quarter focuses on testing and refining the prototypes as well as completing the business plans. The senior design conference and the business plan competition occur during this quarter. The deliverables for this quarter are the final prototype, business plan and final presentation at the senior design and business plan conferences. The class schedule for the Spring quarter can be seen in Table 3.

Table 3. Spring quarter IMPaCT class schedule.

Class	Topic
1	Teamwork
2	The parts of a business plan
3	Moot-Corp video examples
4	Teamwork
5	Team Presentations of Testing Results
6	Dress rehearsals
7	Course Exit Questionnaire
8	Team Presentations of Project and Business Plan
9	Senior Design Conference
10	Final Written Report / Business Plan Due

### Skill Modules

In addition to the lecture topics and assignments listed in the previous section, the IMPaCT program also includes a selection of individual skill modules. These modules allow the students to personalize their learning. For instance if a student wishes (or needs) to know how to properly solder, there is a short skill module the student can complete that will instruct the student in the proper technique. There are a variety of skill modules and more are added each quarter.

### Product Development

One of the foundations of IMPaCT is exposure to the product development process over the course of an academic year. Students begin with an idea and develop a working product that addresses that idea. The ideas for the IMPaCT projects may be based on faculty research, Louisiana Tech intellectual property, industry partners, or the students themselves. During the 2006-07 IMPaCT program, the six projects were drawn from all of these sources. The teams are presented a short description of each idea and choose their favorites. Students are also given a choice to present their own potential projects. The IMPaCT advisory team assigns the student to teams based on a variety of factors including major, interest, and personality type.

The student teams take the idea assigned to them and brainstorm a multitude of concepts to address the problem. Next, the teams develop Product Design Specifications (PDS). A PDS is similar to a checklist of minimum (or maximum) requirements and specifications. Based on their PDS and concepts a spatial prototype is developed that demonstrates the relative size and location of the concept's components. During this time the teams are gathering information and planning their project. The next step is to begin refining their prototype into a working prototype suitable for testing and evaluation. By the end of the second quarter, the teams have a working prototype that demonstrated the functionality of the product. During the third quarter, the teams



test and refine their prototype by using a series of physical tests as well as focus group tests. By the end of the IMPaCT course, the students have built and tested their final prototype and present the product at the Senior Design Conference.

### Business Planning

Not only do the IMPaCT teams develop, build and test a product to meet a certain need, but they also create a business plan for this product. Referring back to Tables 1 – 3 you will notice several business topics on the class schedule. Also, recall that there are business students on the IMPaCT teams along with engineers and other majors. In addition, during the second quarter there is a separate course offered that covers business plans exclusively. As part of the requirements for the business plan course, those students assist the IMPaCT teams with portions of their business plans.

IMPaCT students learn about such topics as marketing, market size, value propositions, and how to prepare a business plan. By the end of the project, the students have prepared a business plan for their product and have entered that plan into the “Top Dawg” business plan competition. Other students from across campus may also enter this competition and it is not automatically assumed that an IMPaCT team will win. As further incentive to compete in the business plan competition, there are sizable cash awards.

### IMPaCT Experiences

As of January 2007, there have been nine IMPaCT teams (three pilot teams and six full-scale teams). These teams have ranged in size from three to six members and have worked on a variety of projects. Some examples of the projects to date include a home-based biodiesel production facility, real-time water chemistry analysis, a technique for improving the coal to gasoline process, and a portable device for the relief of migraine headaches. These projects represent faculty research, industry sponsorship, and student generated ideas.

The goal of IMPaCT is to expose students to real-world situations by creating multidisciplinary teams of students solving real problems. One such team, Spect-Check, consists of an electrical, mechanical, and two biomedical engineers teamed up with a business student. These students designed and built an on-the-spot soil sampling device that can be used to determine if there are any contaminants in a sample of soil. Currently, this type of soil sampling is done by taking a soil sample and sending the sample to a lab for further analysis, which is costly and time consuming. The IMPaCT team applied faculty research to produce a working prototype of their product. Also, the team wrote a compelling business plan and has an industry sponsor interested in continuing the project. This is just one example of the success of the IMPaCT program. This team will also compete in the business plan competition for a chance to win a cash award which they can use to help fund any further product development that they want to pursue. There are many such examples of the success of IMPaCT teams which can be found at the IMPaCT website: [www.IMPaCTLaTech.com](http://www.IMPaCTLaTech.com).

## Support Structures

The IMPaCT program is built around several supporting programs. Some of these programs include the CEnIT, our Business Incubator, our business plan competition, and several classes. As mentioned earlier, CEnIT is the Center for Entrepreneurship and Information Technology. CEnIT was formed in 2001 with funding from the state and NSF's Partnerships for Innovation grant. This center creates a direct connection between the College of Engineering and Science and the College of Administration and Business. IMPaCT is a direct result of this multidisciplinary connection. The Business Incubator provides physical space and support for start-up companies. The business plan competition provides an opportunity to compete for start-up money as well as space in the Business Incubator for deserving teams.

Finally, there are several classes that support IMPaCT. These classes include Innovative Venture Research and Entrepreneurship for High Tech Start-ups. The Innovative Venture Research (IVR) course creates "InVenture" teams composed of business and engineering students, pre-college students, faculty, and external mentors work to develop effective strategies for commercialization of new technologies being researched by faculty. Several IMPaCT projects have come from ideas generated in IVR courses. Entrepreneurship for High Tech Start-ups is a course in which teams of students from all majors develop business plans for technology-based products. Teams from the High-Tech Start-up class will often aid IMPaCT teams in writing their business plans.

On the engineering side of support classes there are Special Topics courses that are offered which allow a student to earn technical elective credit hours for participation in an IMPaCT project. An example of this is a chemical engineering student spending a quarter designing a reactor for the IMPaCT project involving the improvement of the coal to gasoline process. This student is part of the IMPaCT team, but is not required to attend IMPaCT classes, instead the student is required to design and report on the reactor design. Other Special Topics courses can be offered as needed to fill in any gaps in the IMPaCT team members' technical knowledge.

Another very interesting support structure is a recent collaboration with students at "a University" in Taiwan. An IMPaCT team is developing a prototype product in collaboration with a Taiwanese team. The Taiwanese team is part of a Design for Manufacture" course that requires them to take a product prototype and evaluate the manufacturability of the product. The IMPaCT team will make changes to their prototype in order for the product to be more easily manufactured. This collaboration occurs primarily over the internet through file sharing, email and virtual meetings. It is our goal to continue and increase this type of collaboration in the IMPaCT program.

## Challenges

The IMPaCT program has faced several challenges in attempting to integrate a multitude of majors all working together on the same project. Two of the main challenges are scheduling classes and attracting and retaining majors outside of engineering.

## Scheduling

With so many different majors represented in IMPaCT teams it is very difficult to schedule a class time that does not interfere with some other course or commitment. Since it is vital that the senior engineering students be able to complete their senior design credit hours, priority was given to selecting a time in which there would be no conflict. This was actually the easiest challenge to overcome. The solution was to have all engineering senior design courses offered at the same time. Currently all senior design classes are offered on Tuesday afternoons (or Tuesday and Thursday); this is the same time that IMPaCT classes are taught.

The second priority was to find a way to allow as many other students as possible the ability to participate. This problem was address by allowing elective students to participate on a quarterly basis instead of requiring them to enroll for an entire year. Students can participate as often as they want to and as their schedule permits. Currently a student earns one credit hour per quarter of participation. Also, if a student wishes to remain on an IMPaCT team, but their schedule does not allow them to attend the IMPaCT class the assignments and lecture materials are available through the IMPaCT website. These students are held responsible for the same material and are still required to participate in team meetings.

## Attracting and Retaining Other Majors

It is relatively easy to attract senior engineering students to IMPaCT. These students have been working in teams throughout most of their college classes and are required to complete some sort of year-long capstone project. However, other students are not as accustomed to working on teams and are not required to complete a course like IMPaCT. Business students do have a natural connection to IMPaCT through the entrepreneurial aspect of IMPaCT, though it still remains difficult to retain business students for the entire year. These problems are being addressed through increased publication across campus through flyers, webpages, internal television ads, and public showcases of IMPaCT projects.

There are also efforts to incorporate other majors into IMPaCT projects on a short-term, just-in-time approach. For instance, graphic arts students may come in for a week and as a requirement for one of their classes they produce an advertisement, or box-art, or concept drawings for an IMPaCT product. Perhaps technical writing students may come in and create an owner's manual for an IMPaCT product as a class requirement.

Initially, it was believed that it would be necessary for students to remain on their IMPaCT project for the entire year. But, it has been seen that it is not necessary that all students are retained for the program to be successful. There will always be a core group of engineering senior design students who will remain with their project for the entire year as a requirement for their curricula. This core group provides a stable foundation for the project. Additionally, there are several business students who have remained committed to their project for the entire year. Also, the support classes mentioned earlier provide other sources of students for IMPaCT projects as needed.

## Vision for the Future

It is our goal that IMPaCT continue to grow and evolve as a program. There are several strategic goals that we are working toward. More assessment data must be collected and reviewed. The IMPaCT webpage must be updated to include all of the necessary materials for duplication of the program at other schools. Additional skill modules must be developed to provide greater flexibility for students to specialize their learning. Multidisciplinary partnerships across campus must continue to be sought out, such as with graphic design and technical writing. Industry sponsors must be found and encouraged to support the IMPaCT program. Finally, start-up companies must be created from IMPaCT projects. IMPaCT has shown itself to be a viable program already, and reaching these goals will allow IMPaCT to continue to grow and be successful.

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