

**2006-598: IDENTIFYING AND IMPLEMENTING PROJECTS FOR A
MULTIDISCIPLINARY ENGINEERING DESIGN PROJECTS COURSE AT
CARNEGIE MELLON**

Cristina Amon, Carnegie Mellon University

John Wesner, Carnegie Mellon University

Richard Hoff, Carnegie Mellon University

Identifying and Implementing Projects for a Multidisciplinary Engineering Design Projects Course at Carnegie Mellon

Abstract

This paper describes the process of identifying, selecting, and implementing sponsored projects in a multidisciplinary *Engineering Design Projects Course* at Carnegie Mellon University. In order for the course to be most effective, the projects made available to student teams in a multidisciplinary projects course need to have several characteristics, including being “realistic” (i.e., needed by someone), having multidisciplinary aspects so that all team members can contribute, and allowing for significant results within a single semester. At the same time, each project must have the potential to produce useful results for the sponsor, while not requiring unreasonable contributions, and be priced appropriately. This paper shares the lessons learned as we have managed these, at times, conflicting issues in a course which has been successfully offered for twelve semesters and involves a mix of one-time and repeat sponsors from industry, government agencies, non-profits, and the university community.

Introduction

We have previously described¹ a course sponsored by the Institute for Complex Engineered Systems (ICES) at Carnegie Mellon University, a continuation of the former NSF Engineering Design Research Center (EDRC). This is a project-based engineering design course that is open not only to Carnegie Mellon College of Engineering students, but also to the entire campus community. This is one of a series of courses offered at Carnegie Mellon which integrate design education, research and engineering practice²⁻⁴.

The *Engineering Design Projects Course* is unique because it allows teams of upper class and graduate students from several academic areas, including the humanities, business, and fine arts in addition to various engineering disciplines, to work on design projects sponsored by industry, government agencies, non-profits, or organizations within the university. The intent is to give the participating students a hands-on, integrative, multidisciplinary experience in the important field of engineering design.

The success of this course is attested to by several project sponsors returning for repeated semesters with additional problems to be addressed by student teams, and by some students taking the course for a second time, usually working on different projects. Students also indicate that discussions during successful job interviews have focused on this course experience.

The key to this success is providing the student teams with projects that are realistic, meaningful, and of such a scope that they can make sufficient progress in one semester, feeling good about what they have accomplished and, at the same time, insuring that project deliverables are of value to the sponsors.

Course Mechanics

Identifying Potential Sponsors and Projects

Over the six-year life of this course we have learned about potential projects in a variety of ways, including

- Current project sponsors who wish to continue with the same project or a new one;
- Former project sponsors who might be interested in sponsoring another project;
- Companies with who ICES has developed other relationships (e.g., research contracts);
- Potential sponsors identified by course faculty;
- Word of mouth.

This latter group includes companies, non-profits, and even individuals with an interest in engineering design education as it applies to product and/or process development.

All of these clearly fit under the umbrella of *networking*. To date, we have not attempted any formal advertising, either targeted or general.

When a potential sponsor has been identified, the next step is to provide them with more details about the course and the characteristics of previously successful projects. We show our Course Description to those who are unfamiliar or only marginally familiar with the course:

The concept of the course is that multidisciplinary teams of 4 to 6 students work together on projects sponsored by industries, government agencies, non-profits, or university units. Past projects have been sponsored by Eaton Cutler Hammer, Medrad, Mine Safety Appliances, Westinghouse Electric, the American Respiratory Alliance, the U.S. Federal Aviation Administration, the Carnegie Mellon Entertainment Technology Center, the Carnegie Mellon Architecture Dept., and an individual alumnus who wanted to create a restaurant offering the “perfect Southern Barbecue”. The design tasks have ranged from devising a means for giving injections more easily to simplifying the design of a unique computer game console.

As they work on their projects, student team members learn and then put into practice Teaming, Project Management, Product Realization, Ethics, and other skills practiced by product developers in industry.

A typical team may have three engineers from different departments (perhaps two undergraduates and a graduate student), an undergraduate industrial design student, and a graduate student in the English Department’s Professional Writing program. We have also had architecture students, art students, Human-Computer Interaction Institute students, and business majors in the class. Students from all fields have had exciting experiences working together, applying all of their varied skills and experiences to address the many aspects of a “real world” problem.

Potential sponsors who at this point believe there might be basis for their participation in the course are invited to discuss what sort of project they might want to sponsor, and the level of involvement (financial and direct support) that would be expected of them as project sponsors. These areas are discussed below.

Sponsors have represented corporations, government agencies, non-profits, and the university community. Many corporate sponsors have been local; others have come from across Pennsylvania and beyond. Local sponsors can, of course, work more directly with the students. A strong motivation for engaging Pennsylvania corporations as project sponsors is the ICES

partnership with PITA, the Pennsylvania Infrastructure Technology Alliance program. PITA is sponsored by the Pennsylvania Department of Community and Economic Development (PA DCED) as part of an overall economic development strategy designed to capitalize on technology development to transform the competitive environment for Pennsylvania companies. PITA's goal is to support companies in established and nascent industries by encouraging graduates from Pennsylvania's universities and colleges to seek employment in the state. While this does not prevent us from accepting as project sponsors large global companies or companies that do not operate in Pennsylvania, it does encourage us to seek projects from companies who can help meet PITA goals. In return, the Commonwealth of Pennsylvania benefits from improved student retention opportunities, direct transfer of university-developed technologies to Pennsylvania companies and the integration of ICES multidisciplinary research outcomes into ICES course offerings.

The availability of the PITA partnership gives us more leeway to accept projects from non-profits and members of the university community, from whom we do not ask a sponsorship fee. We can utilize PITA grant funds to provide the needed course support for these unfunded projects. (See *Sponsor Costs*, below.)

Goals for Project Selection

As we discuss with a potential project sponsor the sort of project they might offer to a student team and what they can expect to receive at the end of the project, we emphasize the importance of student experiences, including:

- the need for projects that can be brought to meaningful results in one semester (or two)—including a physical or CAD prototype, if possible;
- the need to engage all members of a multidisciplinary team; and
- the need for projects that can be attacked using the project management and design tools presented in class.

In addition to favorable project characteristics, we stress the need for full and meaningful participation by students regardless of their disciplines. In general, all of the members of the student team want to:

- believe that they can contribute to the project,
- be challenged but not overwhelmed,
- feel at the end of the semester that they have accomplished something real and tangible,
- have “fun” carrying out the project.

In addition to defining the project, we also ask that the sponsor give serious consideration to how the results will be useful to them, and be supportive of the course, the project, and the student team

Sponsors benefit by receiving “useful” results for their contribution of ideas, time, and money. Results are typically unencumbered by limitations imposed by corporate cultures and are typically described by company sponsors as evolutionary, as opposed to revolutionary, solutions. In addition, companies benefit by receiving regular and positive exposure on campus, as well as access to students in a situation similar to the work environment. As such, the course project provides sponsors with the opportunity to observe student personalities, work habits and skills as a prelude to hiring. Several project sponsors have hired students (for summer internships and full-time positions) after observing their performance in the project course environment. Likewise, students have the opportunity to learn about job openings and the culture of a given industry or corporation before accepting a job

The Value of a Good Experience

A sponsor having a “good experience” is an invaluable aid to obtaining future projects. Once the sponsors have had a “successful” project experience, it becomes much easier to enlist them in sponsoring another project. This is especially true if the sponsor’s representative who worked directly with the students has had a good experience. Such an individual either finds another project in their own organizations, so they can remain involved with the course for another semester, or they become our advocate, encouraging their management to find another project to sponsor—even if someone else will be the person to work with the students.

Sponsor Costs

The most significant cost to a project sponsor is the time commitment by one or more “client representatives” to work with the student team throughout the course of the project. This includes meeting regularly (weekly, if possible) with the students, and attending at least four of the weekly class sessions:

- the third class of the semester, to describe their project to the student teams;
- two formal Design Reviews, which are intended to give the students realistic industry experience and potentially some useful guidance for continuing their work;
- the Final Presentations, on the last class day of the semester.

We ask a project sponsorship fee of \$7500 per semester. Non-profits, start-up companies, and university units are not asked for a fee, but are expected to participate meaningfully with both students and faculty members to ensure positive outcomes.

The \$7500 includes an allowance to each team of \$2000 to purchase materials necessary to complete project work, including materials to construct a prototype of their design. In general, project sponsors contribute (lend) existing products, materials from which to fabricate a prototype, and even labor to assist in prototype fabrication. A good example of this is one repeat sponsor who has provided special parts made on its in-house stereolithography machine.

A \$1500 honorarium is provided to faculty members who serve as Faculty Coaches to project teams, usually in the form of discretionary funds. The remainder of the fee goes into an educational account to support operations of the course. This money is typically used to buy student materials and pay the Faculty Coach an honorarium for projects that are not directly funded by their sponsors, and to cover overages for course projects that exceed budgetary expectations.

Comparison with Other Courses

Four related project courses were investigated to see how they manage some of the same issues⁶⁻⁹.

Identifying Potential Sponsors and Projects

One of the four courses considered is large; it implements about fifty projects per year in a required undergraduate course. The course's primary source of projects is their advisory committee, which has representation from about fifteen companies in the area. When the course director begins looking for projects he first calls the members of the advisory committee. These members are leaders in their companies, who can influence and authorize their staff to create projects. This core provides between one to four projects per year per company. The course director observed that this is a lot of work and it takes time, but it has been very successful.

Next, the course director tries the course's alumni network. He has maintained contact with about 25 percent of the course's graduates. The course director asks if they have any back burner projects. This is only about 25 percent successful, because these people may want to help but may not yet be in a position in their companies to be able to make it happen.

The second program is more comparable in scale to the project described in this report, with seven or eight projects per year. Most of the projects come through word of mouth; the people running the course are fortunate to have an extensive network of potential sponsors. In addition, the campus research center that supports the course publishes a periodic newsletter, one issue of which is focused on recruiting project sponsors. A campus product development forum has also been a good contact for attracting new sponsors.

This program, too, takes maximum advantage of sponsors who have good experiences and want to continue working with the program. After the end of classes in the spring and also late in the fall, the course director contacts the current project partners by phone or visit, to try to re-engage them.

The third program⁹ is similar to but somewhat smaller than the one described in this report. More emphasis is placed on "nuts and bolts" projects that can be completed in a single semester. The course director used his own ability to envision a possible solution as one of the criteria for project selection. He uses alumni and the university's development office as sources for

potential projects, and places great value on getting repeat projects from a single sponsor. The project director sees this as strongly indicative of the value perceived of the course by the sponsor.

The fourth program⁷, at a still smaller school, has multiple teams working on the same single project each year. Most of the projects have come from within the school; several others have come from non-profits in their community. The potential sponsors are solicited personally by the faculty member in charge of the course.

Sponsor Costs

On the recommendation of its advisory committee, the largest program asks for no more than \$5000 per project per school year. This typically permits a lower-level corporate manager to approve the expenditure. If a company sponsors two projects in the same semester, it is charged a smaller per-project fee. Its fees are likely to go up in the near future and the company finds that it is coming too close to not having ends meet. Several sponsoring companies have provided gifts/grants to help subsidize the course, over and above the project fees.

The second program charges a project sponsor a fee of approximately 13% more than we do. For those sponsors requiring long distance travel (e.g., outside the continental United States), they ask for a travel supplement. In other cases where more prototyping, etc., may be required, they also ask for a higher fee. The course only realizes about 65% of the fee to support the project and the course; the rest goes to the university and the sponsoring department.

Faculty coaches for this program receive the same honorarium that the course described in this report offers for each project team mentored. Teams usually have a base budget of \$3,000 for supplies, plus an appropriate travel budget. Last year, three teams traveled offshore to present their results to the sponsors.

Sponsorship fees in the third course are very similar to the course described in this report. Some of the logic used by the first course described above is applied here, in setting the requested level of company contribution.

The fourth program carries out its projects on a *pro bono* basis. Faculty members who participate, including a coach for each student design team, receive teaching credit but no special remuneration.

Conclusion

A major challenge for a university project course is identifying and cultivating relationships with prospective project sponsors to provide a continuing flow of real and meaningful experiences for students. The ICES-sponsored *Engineering Design Projects Course* at Carnegie Mellon University has met this challenge by understanding the needs of the students and the project sponsors, and insuring that expectations by both constituencies are achievable and understood by everyone involved in the course.

Building a network of repeat project sponsors seems to be key. Two similar programs at other universities also rely strongly on networking, especially with current project sponsors, to secure future projects. One of them charges somewhat less for course sponsorship, to lower the level of management approval needed to sponsor a project.

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