An Extension Service Approach to Industry-Sponsored Senior Design Projects

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Abstract

The Mechanical Engineering (MCHE) Department at the University of Louisiana at Lafayette (UL Lafayette) has recently made the commitment to focus its Senior Design course more toward solving real-world engineering design problems for local industry through the Manufacturing Extension Partnership of Louisiana (MEPoL), rather than toward entering design competitions. The benefit of this change is that the students get a more realistic design experience while local industry gets the engineering support that it needs to be more competitive. During the Fall 2002 semester, MCHE students from UL Lafayette began working on two assembly-line automation projects for MEPoL clients. This paper describes the progress made and the challenges encountered as this transition from design competition to real-world projects has taken place, and focuses on the benefits of using an extension service as a vehicle for industry-sponsored projects.

Introduction

Many engineering departments require a major design project during the senior year. This “Senior Project” is often called a “Capstone Design” experience, because the project is meant to be the culminating event in the educational career of the students, providing an opportunity to put into practice many of their newly-acquired engineering skills in the context of a single major team design project. Various researchers have identified different factors that contribute to a project’s success^{1,2,3}, but the factor we will deal with here is the choice of project type. We will first discuss the pros and cons of design competition vs. industry-sponsored projects. Then we will relate our experiences as we have transitioned our senior design course from a competition-oriented course to a course oriented more toward solving industry-sponsored projects. Although many researchers have discussed the potential difficulties associated with industry-sponsored projects^{4,5,6}, little has been said about the use of a university extension service approach to resolving those issues. That is the focus of this paper.

Design Competition Type Projects

In many cases the project chosen deals with a national design competition sponsored by one of the major engineering societies, such as the American Society of Mechanical

Engineers (ASME), the Society of Automotive Engineers (SAE), the American Society of Civil Engineers (ASCE), or others. Some of these classic design competitions, such as the SAE Mini Baja competition⁷ and the ASCE/AISC steel bridge building⁸ and concrete canoe competitions have become beloved traditions at many schools across the country. From an academic perspective, choosing one of these design competitions as a design project has many advantages. One advantage is that the competition aspect provides an external motivation factor that often results in the students willingly putting forth a far greater effort than would normally be expected for another course of similar credit hours. Another advantage is the fact that the professor does not need to put forth much effort to define an appropriately-scoped project for the students. There are enough design competitions available so that the professor can choose one that suits the level of and structure of the class. A further benefit is the fact that if the student team happens to fail to solve the problem properly - if the car breaks down or the bridge fails or the canoe sinks – there are few negative consequences (beyond some injured pride and maybe a lower grade), since it was after all only an academic exercise.

Industry Sponsored Projects

Another alternative is to select industry-sponsored design projects. There are many benefits to such a choice, but also certain drawbacks. One benefit is that the students are provided with a very realistic design experience. Rather than simulating what might be done in the “real world,” the students actually enter the real world by working on engineering projects that are really needed by industry. Knowing that there is a real live client who really needs the product to be designed provides a motivating factor for the student at least as strong as design competitions, and results in a similar outpouring of creative energy. Another potential benefit is that the students make industry contacts that might be helpful during their job search, and become accustomed to interacting with practicing engineers and managers. Obviously, another advantage is that solving problems for local industry assists the university in its economic development and public relations efforts, and assists the company to become more competitive. Another advantage is that in some instances, the sponsoring company may pay a fee or make a donation beyond the cost of materials that can be a significant boost to the laboratory maintenance budget of the academic department⁵. Thus an activity that is usually resource-consuming might actually become resource-generating.

There are also certain drawbacks to selecting an industry-sponsored project. One major drawback is the fact that the stakes are much higher than for a design competition. If the students lose a race, they may be sad, but if they fail to deliver in a timely manner the product for which the client has paid good money, the client may lose market opportunities worth far more than the cost of the device to be designed, and any public relations benefits for the school will be lost. Other researchers have noted the difficulty of finishing a complete industrial project in one semester⁴.

Realizing the potential benefits and drawbacks of industry-sponsored projects, the Mechanical Engineering Department at UL Lafayette recently began a move toward the

use of industry-sponsored senior projects. The sections below will describe the issues that were encountered during this transition time, and highlight the role of MEPoL in resolving some of those issues.

Gaining University Approval

The first obstacle we encountered was to obtain university approval to pursue the goal of using industry-sponsored projects for the senior projects class. Although senior projects had occasionally been performed for industry in the past with no university objection, officially asking for approval turned out to be a larger issue than had first been envisioned. This section will address several issues that must be addressed before university approval for the use of industry-sponsored projects can be expected.

Competing Claims for Intellectual Property Rights

One issue that must be resolved is the question of who will own the intellectual property rights for any designs or products that are developed as part of the senior projects class⁵. In fact, at UL Lafayette, the first rather lucrative possible contract had to be turned down because the university raised issues related to ownership of patent rights that the sponsor found objectionable. The university tended to look upon this activity in the same light as a research project. For research projects, the university regularly asserts that it owns the intellectual property rights for products arising from university research projects. Usually this is not a problem, since the projects are government-sponsored and the government is usually willing to give up its property rights. In fact, the government is usually quite happy to allow the university that developed a technology to patent or otherwise protect the technology, as a way to promote technology transfer and economic development. Usually the university will patent the technology and then immediately license the rights to an outside company that will actually develop and market the product. Sometimes that company is spun off from the university, being founded by one or more of the professors who worked on the project.

However, when industry provides most of the funding for a project it naturally wants to reserve all property rights unto itself. Industry tends to see the issue as one where they have paid someone to build a custom device to meet their requirements. Having recognized the need for the product, initiated contact with a “consultant,” and having commissioned the project and paid for it, they see no reason to give up any of the property rights. Of course, the truth of the matter is that the university subsidizes the development of the product by providing the student and faculty labor and often machining and assembly facilities at a fraction of the cost that it would cost on the open market. On the other hand, there is a general expectation that a state-supported university should provide help to local industry for as part of its mandate and justification for receiving tax dollars.

In an effort to resolve these conflicting points of view, it is important to note some fundamental differences between an undergraduate-level design project and a research project. Most senior design projects would not qualify as a Master's thesis because they are more development oriented than research oriented. The project may result in a novel product, but not necessarily in an advance in the state-of-the-art. The students may very well simply put together off-the-shelf components to solve a customer's problem. Also, although some of the projects might actually be able to be patented, they might well be more properly protected by trade secret, since they represent custom equipment designed to fulfill a particular need in a client's plant, rather than a product for which there will ever be a mass market.

Liability Issues

Another issue that must be addressed by the university before giving approval for industry-sponsored projects is the question of liability. It is true that the university might be held liable if someone were injured while operating a machine designed by a student. However, it must be also recognized that liability for senior projects is a matter that the university must always face whether the project is competition-oriented or industry-oriented. For example, the university faces the same legal exposure if someone is injured while a student is operating a competition-oriented project such as a mini baja vehicle. Even if there were no design failure, the car operated by a student could careen off the track and strike a spectator. Or, as another example, the suspension system could fail, the car could crash, and the driver of the vehicle could be injured. In either case, the university would be exposed to some degree of legal risk. Therefore, it cannot be argued that liability issues by themselves disqualify industry-sponsored projects in favor of competition-oriented projects. Still, to the extent that more persons outside the university could potentially be affected by industry-sponsored projects, the issue of liability should be seriously addressed.

Professional Responsibility

The issue of professional responsibility must also be addressed. When engineering services are offered to the public, those services must be performed by or under the "responsible control" of a registered Professional Engineer (PE)⁹. Since in most states the teaching of engineering design is also defined as the practice of engineering¹⁰, the professor who teaches an engineering projects class will almost always be a registered PE. Therefore, if necessary, the professor could sign off on the design as the PE in charge.

With regard to personal professional liability for the professor, many engineering professors supplement their university salary by serving on occasion as engineering consultants to local industry. In that case, the professor will probably already carry Error and Omissions (E & O) insurance. However, many university professors do not carry their own E & O insurance, and would not want to do so just for the sake of a projects class. Other professors may simply not want to put their own professional reputation on the line for work performed by students.

It should be recognized, however, that many projects that would be suitable for a senior project would not require a PE's signature at all. For example, the output of many senior projects would be a prototype of a product that the company would then refine and produce under its own authority. In that case, depending on the rules of the state PE board, the prototype design may qualify as a "preliminary" design, and thus would not require a PE's seal¹¹. A similar approach was taken at one school, where the potential client was informed upfront that, "the projects are NOT run or directed by the faculty and, as such, are not "certified" projects that include PE approval.⁴"

Competition with Professional Engineers in the Community

Another issue that the university might raise is whether it is appropriate for the university to be competing for consulting jobs with Professional Engineers in the local community. Clearly, it is not generally within the mandate of a university to compete with local businesses, but rather to support them and to promote the economic development of the region that it serves. In this effort, most universities offer outreach or extension services to the community they serve. Many state universities, for example, offer agricultural extension services to local farmers at low or no cost. It could be argued that doing so takes jobs away from private consultants who might do the same job, but the practice has long been accepted as one of the proper roles of the university. Offering engineering services to the community at low cost can be also seen as a type of extension service, where the expertise of the university is brought to bear to improve the economic conditions of the state. More will be said about this later.

The operative question, therefore, is will the projects done by the seniors really take business away from the engineering consulting firms in the community? We think not. In general, the projects chosen for a senior projects class will be of such a size, scope, duration, urgency, and volume that the consulting firms would not likely be interested in or adversely affected by the projects undertaken by the students⁶.

A peripheral issue that might possibly be raised is the question of whether or not it is a violation of engineering ethics to offer engineering services at discounted rates. Some engineers still think of this as "unfair competition," and a violation of engineering ethics. Such is simply no longer the case. It is true that the code of ethics for the National Society of Engineers (NSPE), and the codes of most of the other major engineering societies, for many years contained one or more canons to the effect that, "The Engineer will not compete unfairly with another engineer by attempting to obtain ... professional engagements by competitive bidding."¹² Other canons forbade accepting a job at less than the going rate for a particular geographic region. However, in 1978, the U.S. Justice Department sued the NSPE and the other major engineering societies under the Sherman Anti-Trust Act, and declared that such practices amounted to "price fixing," and were illegal. Most of the societies reached an out-of-court settlement, but the NSPE continued the court battle and lost. The order entered by the court is quoted below:

By order of the United States District Court for the District of Columbia, former Section 11(c) of the NSPE Code of Ethics prohibiting competitive bidding, and all policy statements, opinions, rulings or other guidelines interpreting its scope, have been rescinded as unlawfully interfering with the legal right of engineers, protected under the anti-trust laws, to provide price information to prospective clients; accordingly, nothing contained in the NSPE Code of Ethics, policy statements, opinions, rulings or other guidelines prohibits the submission of price quotations or competitive bids for engineering services at any time or in any amount.¹³

The above decision was subsequently upheld by the U.S Supreme Court. Therefore, it is emphatically *not* a violation of engineering ethics to offer bids for engineering services “in any amount,” high or low. The only question in this context is whether it is within the mandate of the university and beneficial to the overall community to do so.

Resolution of Difficult Issues Through MEPoL

At UL Lafayette, many of the difficult issues discussed above were resolved through the mediation of the Manufacturing Partnership of Louisiana (MEPoL)¹⁴, a State of Louisiana and National Institute of Standards and Technology (NIST) funded outreach program housed at the university. MEPoL’s mission is to provide low-cost assistance to manufacturing companies in the state, in an effort to bolster that segment of the state and national economy. University professors are encouraged by the administration to support the MEPoL program by providing discounted consulting services to local manufacturers, and on such projects the university makes no claim on the intellectual property rights. The client retains the intellectual property rights for any work performed under the umbrella of MEPoL. By extending the definition of a “consultant” to include any students working under the supervision of a faculty member, the university was able to rationalize not making a claim on the intellectual property rights. Before approving this more flexible definition of “consultant,” however, the university required documentation from other Manufacturing Extension Partnership (MEP) programs in other states indicating that such was in fact a standard practice.

Working under the MEPoL umbrella also addresses the liability issue, because MEPoL carries professional liability insurance that covers all of its consultants, eliminating the need for the professor to carry separate a insurance policy. In addition, the issue of competition with outside industry is resolved because the state and federal governments have both agreed that it is appropriate to provide engineering services at discounted rates to clients that qualify for MEPoL membership.

There are many other practical advantages to working under the MEPoL umbrella. One such advantage is that the approval process for each new project becomes vastly simpler. Instead of needing to have two or three comparatively small contracts approved up through the research office channel to the university president each semester, a simple two page MEPoL “task” is created between the professor, MEPoL, and the client. Under

this arrangement, the consultant ultimately works for MEPoL, and MEPoL assists the client by providing consultants to perform the work. One natural advantage to this is that the MEPoL field agent can act as a mediator if there is any trouble interpreting the scope of the “task.” Another advantage of this arrangement is that MEPoL takes care of all the billing and collections, guaranteeing payment to its consultants, even if the company defaults on payment to MEPoL. The advantage of this for a senior projects class is that MEPoL guarantees that the engineering department will receive payment for the senior project even if the client fails to pay the bill to MEPoL. A further benefit to working with MEPoL is that they take care of the advertising and bring clients to the table that already have problems that need to be solved, thus freeing the professor from the need to seek projects among his or her own industrial contacts.

Bidding the Jobs

One of the more difficult decisions regarding the change toward sponsored projects had to do with deciding how much to charge the client for the work. One school has charged everywhere from \$500 to \$50,000 for a two-semester industrial senior design project, depending on the scope and material costs⁴. Another school charges a standard \$15,000, based on a projected 800 – 1000 man-hours over two semesters, which is used to buy $\frac{1}{4}$ release time for the professor to supervise the project¹⁴. In our case, however, we would have had a hard time hiring an adjunct to take over the professor’s other classes, even if the customer demand were there, so a lower amount was selected. On a trial basis, therefore, it was decided to charge \$5000 for a one-semester project with five members on the team. As a precaution, however, we wrote the MEPoL task so that we could take up to two semesters in the event that we were unable to complete the task during the first semester. In consultation with the client, we tried to scope the project so that it would take about 10 hours per week for each of the 5 students, for the duration of the 15-week semester, or 750 man-hours total. We also tried to scope the project so that no more than about half of the income would have to be spent on materials, leaving some residual to upgrade the laboratory facilities. On this basis, we bid for and were approved for two projects from two different MEPoL clients. Each project was of the nature of assembly line automation, where a manual assembly process was to be automated.

Communications and Deliverables

The MEPoL tasks were written so that an interim design report would be delivered about halfway through the project, and a final report and project demonstration would be delivered at the end. The MEPoL field agent facilitated communication between the university people and the industry people. The students provided oral and written memo reports to the professor once each week, with smaller consultations all during the week. A formal meeting was set up with the clients halfway through the semester to discuss the progress of the project. In addition, informal communication between the students and the client took place throughout the semester using e-mail and the phone.

Difficulties Encountered

It turned out that we encountered many difficulties during the course of the first semester. The first problem was that the university purchasing system was so slow that it seriously jeopardized the success of both projects. With a three-to-four week purchasing cycle for major components, it was very difficult to allow enough time for the preliminary design stage on the front end of the project. Instead, the students were forced to jump to premature design decisions in order to get the parts into the pipeline soon enough to allow construction and testing of the product before installation in the client's facility. As it turned out, there simply wasn't enough time in one semester to do a professional job, so both jobs were continued into the next semester at no additional cost to the client, but also at no additional revenue to the school.

Another difficulty encountered was one of "creeping requirements" on one of the projects. Although the general customer requirements were spelled out in the MEPoL task, and a more detailed description of the requirements was outlined in the midterm report, the customer continued to ask for more and more features on the machine. Eventually, although we bid the project to build a machine that would be a simple slave of another machine, the customer was eventually asking to have our machine become the master controller of an entire assembly line, controlling three other machines in addition to our own. Finally, through the mediation of the MEPoL field agent, all parties agreed upon the scope of the project.

A further difficulty is simply that the projects turned out to be deceptively difficult to solve. As a result, the students ended up putting in far too many man-hours on each project. Figure 1 shows the students working on one of the projects.

Figure 1. Students Working on Industrial Project

Lessons Learned

The main lesson learned was that it is very difficult to do a complete custom design project, using the university purchasing system, within only one semester. As a result, we will be looking for projects that can more appropriately be done in two semesters. A switch to a two-semester project will probably result in an increase in the price. Also, our experience with the scope of the projects will cause us to be a bit more conservative regarding what we are able to do within a particular time period. We also plan to try to formalize the customer requirements sooner and in greater detail so that disagreements over scope issues will be less of a problem.

Summary and Conclusions

In summary, we are experiencing some growing pains in our transition from design competition-oriented to industrially-sponsored senior design projects. We feel that the many benefits of the change outweigh the disadvantages for our situation. Any school attempting to make the change may find that it is not so easy to obtain university approval for the change, due to issues related to intellectual property rights, liability, and

competition with existing consulting firms. In our case, aligning ourselves with the Manufacturing Extension partnership of Louisiana allowed us to address all these concerns and gain university approval.

In spite of the difficulties encountered, the customers and the students are still excited about both projects, and many potential benefits accrue from making the change to industry-sponsored projects, so we plan to continue in this direction. We will be making some changes in the way we bid projects and document the requirements before taking on any new projects in order to overcome the difficulties described above.

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