Engineering Consulting and Development for Start-up and Small Firms in Capstone Courses

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ABSTRACT

The development of products is a costly endeavor, and is often a significant barrier for many organizations to develop ideas to market. Start-up and especially non-profit companies often lack the resources of an engineering development team to analyze, develop and test a product concept. Many engineering schools across the country work with industry to develop projects suitable for their capstone design courses, usually through single major or cross-functional design teams. Others schools solicit projects based on a specific challenge faced by industry and have design teams develop potentially viable solutions. There are distinct pros and cons with each of these approaches as they apply to student learning and application of engineering principles. This paper will describe a successful attempt to bridge the area between these two ends, through engagement with companies that otherwise lack the engineering resources to develop new products. An example of this will be used to stress the unique opportunities with working with new, small, or non-profit clients.

INTRODUCTION

Capstone design courses across the United States are generally structured as a comprehensive finishing course for engineering students. For several years now, Oakland University (OU) has been utilizing a one semester "Melting Pot"[1-3] approach which combines students from the Electrical and Computer Engineering Department and the Mechanical Engineering Department into multidisciplinary design teams. In some of our previous papers about this approach, we described our experience with instructor-designed capstone projects. It is the premise of these previous publications that industrial projects usually lack the cross functional team aspect, can be treated as simply hiring a student to work as cheap labor on a company's project, and not always be a synthesis of the course work of the students. Over the years, the faculty teaching the capstone design course at OU have experimented with different types of project assignments. Some were Instructor Chosen, others Industry Sponsored and, more recently have also come from what we believe to be an untapped source, Start-Up / Not-for-Profit companies. Instructor Chosen projects have been the primary source of projects at OU over the last 13 years, but since the Winter of 2015, project assignments have moved to a mix of the three described above. Some of these changes have been driven by the fact that in the Fall of 2014, the School of Engineering

and Computer Science at Oakland University moved into a new Engineering Center (EC). This new facility contains a new dedicated workspace, the Senior Design Lab (SDL), which now provides students with easy access to design and manufacturing tools that were heretofore not readily available to them. in the SDL students have permanent access throughout the semester to a workstation consisting of a computer with CAD, CAE capabilities as well as electrical and mechanical modeling tools taught throughout the curriculum. Additionally, these stations have electrical test equipment such as power supplies, multi-meters, function generators and oscilloscopes. Students have access to a full machine shop containing both manual and numerically controlled milling centers, laser cutter, water jet and welding capabilities.

In this paper we describe the pros and cons of each type of capstone project (Instructor Chosen, Industry Sponsored and Startup sponsored). A comparison of the student advantages from one source of another will be discussed, as well as the benefits to the field, community and industry.

INSTRUCTOR CHOSEN PROJECTS

In the Instructor Chosen Project arena, the choice of projects is only limited by the imagination of the instructor. Often projects may be chosen without previous exploration by the instructor of potential solutions to the problem described, allowing students to come up with a variety of creative solutions to the problem. As an example, a project that was assigned for the Fall 2014 semester was a part-counting apparatus. In industrial assembly plants, small parts, specifically fasteners, are used throughout the assembly process. These parts are usually presented to the worker in boxes with enough fasteners to allow for multiple assemblies. When an assembly operation requires a certain number, say three, of a particular fastener the worker will reach in the box and grab a few fasteners. The number taken may be greater than the desired quantity (these extra parts are often discarded to the floor), or less than the quantity needed (requiring the worker to either fetch the remainder or not complete the assembly). Each of these situations is a form of waste in the assembly operation.

In an effort to eliminate this waste, the students were to build an apparatus capable of precisely counting and delivering the correct number of fasteners. The device was to be designed such that it could be reconfigured to handle different types of fasteners across the assembly plant. While not a direct industry-sponsored project, the societal impact of this particular project which is targeted at eliminating waste is very poignant. Students were free, as with any project, to take their own path to satisfy the requirements of the project.

These types of projects allow instructors to tailor the specific problem statement to the makeup of the student population and to test the exact skills that have been acquired by the student body throughout their education, which can be a powerful tool for ABET assessment. At Oakland University this was critical as students came from both the electrical and computer engineering as well as the mechanical engineering departments. Additionally, students are usually presented with a problem that the instructors do not have a solution for which allows both the student and faculty to see the evolution to an engineering design. The main drawback of this approach is the requirement for instructors to construct a new problem every semester. This has so far not been an issue at Oakland University, but it is a definite possibility.

INDUSTRY SPONSORED PROJECTS

Industry sponsored capstone projects exist at most universities around the country. These types of projects offer industry a design resource at low cost, as well as an opportunity to give back to the educational community by funding them. These projects can range from low cost projects such as improving existing production equipment to large scale multi-million dollar projects. By finding sources of design projects in industry, instructors are freed from the need to develop a problem to solve and instead can focus on working with industry contacts to help solve their problems. At Oakland University these types of projects have been hard to incorporate into the program, due to the time constraints of a one semester course. Additionally problems for industry are not always cross functional in scope, which can be an issue with the "Melting Pot" structure of the senior design experience at OU.

Industrial sponsored projects offer students the opportunity to work on a real industrial problem, thereby having a sense of satisfaction that the solution derived by their teams has a real world impact. Engagement between students and corporate employers provides valuable corporate experience to students. Opportunities for informal evaluation of potential employees abound, and the companies that fully engage in the experience report high satisfaction with the process.

These types of projects can also lead to a more rigid and proscriptive design experience, and can lead to conflicts between sponsors and students. As an example, some automotive companies require that students employed by them only work on projects sponsored by the company itself, or on a project that is non-industry sponsored to begin with. This limiting factor can be a hindrance to assigning students to teams, particularly at OU where many of our engineering students work as interns in industry throughout the academic year. Another conflicting matter is the need for non-disclosure / non-compete documentation required by sponsors. The interests of the sponsoring company are to protect the work performed as their intellectual property (IP), a complication not present in instructor-assigned projects.

START-UP / NOT FOR PROFIT COMPANY SPONSERED PROJECTS

Like industrial sponsored projects, projects performed for start-up and/or non-profit (SNP) companies offer a rich source of interesting projects, may or may not be cross functional in scope and have the potential to have the same IP issues that corporate sponsored projects present. There is an advantage, however, to working with these types of companies that is quite different from working with well established industrial partners. The typical SNP company often will lack an engineering department and standard practices. Teams working on these projects end up being the engineering department for the sponsor, operating much like a small engineering firm. IP issues with these companies can be easier to handle with solutions ranging from students presumed, split and sponsor presumed types.

It was in the winter semester of 2015 that the first of these types of projects was instituted at Oakland University. Working with the Leader Dogs for the Blind, a non-profit organization, students were divided into teams to work on one of three problems. The first problem was development of a transportation heating crate to maintain the body temperature of an entire litter of puppies during transfer from host family to the medical staff. The second project was a dog

transport lift, which could be used to transfer full grown animals from surgery to their kennels located in the facility. The third project was the development of a new lifting/tilting operating room table and positioning box to be used by the medical staff to perform surgeries on the animals.

This last project, the surgical table, is a good example of the IP issues that can arise. Subsequent to the development, construction and delivery of the tables, a veterinary supplier expressed interest in manufacturing and selling the design. Since no prior formal agreement was in place, the students were the primary owner of the IP, with Oakland University a secondary partner since they supplied funds and resources for the development of the designs, and the client a tertiary partner. Formal legal assignments of the IP rights are necessary to move forward with the manufacturer. This was the setup agreed upon at the project inception, and is of benefit to both the student and the sponsor.

Developing these multidisciplinary products by the sponsor would be a difficult undertaking with any other source. Being a non-profit organization, there exists no engineering department and to develop a solution would require an outside engineering design firm and manufacturer. This would be prohibitive for such an organization and would therefore probably not be pursued. By working with student teams, many concepts could be explored, combined and an evolutionary design developed by having multiple teams addressing the same problem set. This is of advantage for both parties, with the students developing real world solutions and the sponsor gaining access to a resource otherwise unavailable to them.

Another example of this type of project is one that was explored in the fall 2015 semester. The senior design instructors were approached by a start-up company in the Oakland University business incubator. This firm is in the process of developing new storage battery technology focused around inexpensive and relatively safe sodium as an electrolyte. Once the considerable technological hurdles are surmounted to develop the battery cell, several hundred cells need to be constructed, assembled together and taken through several hundred charge and discharge cycles in order to demonstrate their safe and efficient operation. The company did not have the requisite engineering expertise to develop such an experimental apparatus. Two design groups explored alternative designs for this test enclosure, through entirely parametric and scalable parameters since the cell details were not yet fully solidified. The final design was a consolidation of the alternatives, and full parametric CAD models and their costs to construct and operate were delivered to the client.

In the winter 2016 semester, two more small businesses are participating with projects. One involves a newly patented type of battery technology where the battery itself is “stimulated” with specific pulses of electrical energy during charge and discharge, with reported increases in both of 30%. Students are exploring ways to reduce this stimulation to an adaptive, automated operation that can apply to any type of battery. The other involves an Internet-of-Things (IoT) company that is interested in reducing the amount of data necessary to upload as things (buildings, bridges, machine tools, etc) are monitored, yet still retain sufficient information to make important decisions concerning their operating status. A team of students is currently instrumenting a small bench-top metal lathe and will generate the data stream cloud-path, under normal and abnormal cutting conditions, with the goal of identifying the minimum signal components to retain in order to still provide meaningful diagnoses of adverse conditions.

CAPSTONE AT OAKLAND UNIVERSITY – MOVING FORWARD WITH SNP's

Oakland University's capstone course for engineering majors is unique in many different ways. This includes it being a cross functional course, restricted to a one semester experience, and having working students that may restrict the choice of projects they can work on and so on. With instructor selected projects these challenges are easily addressed, and is the primary reason for that method being utilized at OU in the past. Industrial sponsored projects are much harder to incorporate into the course as they often times have one or more restrictions to the "Melting Pot" concept of the OU capstone course. SNP's on the other hand offer an alternative that can address some of the concerns in regards to industrial sponsored projects.

There are two business incubators affiliated with Oakland University. The purpose of these institutions is to accelerate the development of new businesses and offer guidance and resources that would be otherwise unavailable, cost effectively, to these start-up companies. Having access to an engineering team benefits both the company sponsor as well as the students of Oakland University. Students gain knowledge and practice working with a customer, that often times has different goals than the instructors for the project. Students are also provided with an opportunity to apply engineering principles to solve a real world problem and a feeling of accomplishment that it will be instituted in the real world. Additionally, Oakland University faculty and staff gain the opportunity to build working relationships with new customers and can help foster growth of its engineering community reach.

SNP's are an exciting new source for design projects, that until recently was untapped market at OU. The advantages to all involved parties is an ultimate win for everyone involved. Small companies, not for profits and even inventors can gain access to an engineering department that otherwise would be cost prohibitive to them. Students gain knowledge of the entrepreneurial process as well as applying the engineering expertise to solving a real world problem. Faculty are introduced to new opportunities to engage with the community. Moving forward it is readily apparent that SNP's represent a great source of projects for OU's capstone course.

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