AC 2009-1109: CAPSTONE PROJECTS: INTEGRATING INDUSTRY THROUGH STUDENT LEADERSHIP

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Capstone Projects:
Integrating Industry through Student Leadership

Abstract

Capstone projects provide a unique opportunity for developing student leadership skills while integrating industry partners. While models for including industry partners in capstone projects have been discussed in prior literature, these models focus on faculty leadership in developing industry partnerships. This paper describes a capstone project model that encourages student, not faculty, leadership in engaging industry partners. Factors that influence successful project teaming of students and industry partners are identified and described using case study examples. The successes and difficulties of integrating industry in capstone project via student leadership are explored.

Introduction

The Architectural Engineering (ARCE) program at Cal Poly, San Luis Obispo requires all undergraduate students to complete a one quarter long senior capstone project. At the masters level students are required to complete a three quarter long capstone project prior to graduation. The benefits of industry participation in capstone projects has been well documented in prior literature.

This paper explores the student leadership model employed by the ARCE department used to team students with industry partners and identifies the benefits and drawbacks of this model. While many university programs encourage or require students to team with industry partners for their capstone project, a literature review indicates that the ARCE model for teaming students with industry has not been fully explored. The capstone project model described in this paper requires students, not faculty, to identify and develop their own project and encourages students to independently establish industry partners. This paper describes the unique aspects of the ARCE capstone projects model, identifies sources that assist students in successfully teaming with industry partners and uses case studies to demonstrate the benefits and limitations of this capstone project model.

Student Led Capstone Project Model

All ARCE undergraduate students are required to complete a capstone senior project. The ARCE program is somewhat unique since students complete three capstone design courses, one course in each of the major structural building materials (concrete, steel, wood and masonry) in addition to their capstone senior project. The performance of the capstone senior project occurs during one academic quarter (11 weeks). However, students are required to complete their project planning and get faculty approval prior to the start of the quarter. Students, not faculty, are responsible for identification and selection of the senior capstone project topics. Faculty

serve as one-on-one mentors to the students as the students explore and refine potential topics for their capstone project. During the performance of the project, students typically meet weekly with their faculty mentor. At the end of the quarter, students complete a formal written report and make a formal presentation to the entire faculty and other senior students.

All ARCE master's students are required to complete a year long capstone project. Students, not faculty, are responsible for selection and development of an appropriate capstone project. Faculty serve as one-on-one mentors to the students as they develop the topic and complete the design work for their capstone project. At the end of each of the three quarters, students complete a formal written report and make a formal presentation to fellow graduate students and engineering faculty. In addition a faculty member from the English department reviews the written reports and observes the presentations to assist the student in developing professional written and oral communication skills.

Similar to other institutions, the learning objectives for ARCE capstone projects "extend beyond technical ability to include: effective communication skills, planning and prioritization, time management…"[2], etc. as follows:

1) Enhance independent thinking by engaging in structural engineering projects that further develop competencies acquired in pre-requisite courses.
2) Further develop critical thinking skills required to solve open ended problems related to design, analysis, and/or construction of building projects.
3) Further develop skills associated with project management such as developing, implementing, and adjusting a project plan or schedule, clearly defining scope of work, and estimating time and costs required to complete a project.
4) Further develop communication skills required to produce organized documentation, graphic illustrations, professional presentations, and clear and concise project reports.

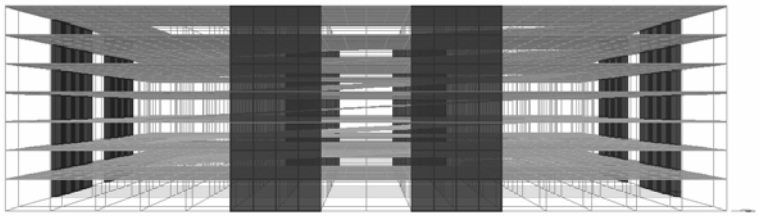
Student Leadership and Industry Partner Teaming

A literature review indicates that many engineering programs rely only on faculty to identify capstone project topics and to create industry partnerships. Recent literature states "projects are identified through discussion between the instructor and one or more company technical personnel prior to any involvement with the students"[1] and that "the student solves a problem identified by an industrial sponsor"[2]. In the student leadership model, faculty do not identify or develop the project topics and scope for the students. Students are required to take the initiative to search out and develop a project of interest.

While the Architectural Engineering (ARCE) program at Cal Poly does not mandate students team with industry partners, the Learn by Doing motto of the university and the department strongly encourage industry participation. With faculty mentoring, a large percentage of students are able to develop a capstone project with strong industry participation. As the capstone project process has developed, several reliable sources for students to find industry partners have included the following:

Summer Internships - The largest source of student-industry partnerships is developed during summer internships. The ARCE program has developed a strong reputation among the structural engineering and building industry disciplines of developing graduates prepared for professional life on day one. The large majority of both undergraduate and graduate students are able to find summer intern positions in structural engineering firms, architecture firms and construction firms. Students are encouraged during their internships to identify a design problem with their employer that can serve as the genesis for their capstone project. A large percentage of students are able to find projects in conjunction with their internship employer.

As a case study example a student recently interned at a structural engineering firm that specializes in cast in place parking structures. During his internship he was asked to assist in evaluating the seismic performance of the non-lateral load resisting framing system. Due to cost and time restrictions imposed on real life engineering projects, the firm was unable to fully explore this topic to their satisfaction. As a result, the student brought this topic and industry partner to his master's project. The student greatly benefited from the active participation of his industry partner. The industry partner benefited by being able to explore a topic directly relevant to their engineering projects beyond what the firm could financially support.



Alumni – The ARCE program at Cal Poly recently celebrated it's 60th anniversary. Many alumni remember fondly the Learn by Doing education that propelled them to success in their professional careers and have a strong desire to give back to the program. While there are many ways to give back, some alumni are able to give back by assisting students in identifying and developing capstone projects. Alumni can serve as an incredible network of contacts in developing interesting and relevant capstone projects.

As a case study example the ARCE department was recently contacted by an alumni with connections to the California Department of Parks. As with many public agencies, the needs are greater than the available resources. A state park near the university had a historic structure in need of structural study that could serve as the basis of a great hands on student project. The state park was able to provide full access to the historic facility for

the student and provide additional support with access to professional architects and engineers knowledgeable about the project and historic structures. A master's level student is currently using the building as the basis of his year long master's project.

Professional Faculty – The ARCE faculty is somewhat unique amongst universities. Over 90% of the tenure track faculty have professional engineering experience outside of acadamia. 80% of the tenure track faculty have a PE license and 40% are seasoned practitioners with both a PE and SE license, and a decade or more of experience. In fact, there is over 100 years of professional practice experience amongst the full time tenure track faculty. Thus, the faculty is uniquely qualified to mentor students in the selection of relevant design projects and guide students to appropriate engineering professionals based on their design project topic.

As a case study example a recent student was interested in investigating the seismic performance of historic steel frame and unreinforced masonry structures. The student was able to team with a faculty member with extensive professional engineering experience in seismic performance of historic structures. The faculty member was able to mentor the student in development of the project scope and appropriate industry partners. As a result, the student was able to engage four professional engineering firms as resources and mentors for her project.

Building Product Vendors – Approximately ¼ of ARCE capstone projects involve construction of building components for testing or the construction of actual building projects. Vendors play an important role, not only providing technical support for the students, but often in donating building products to support the construction activities.

As a case study example, several student groups have developed capstone projects that include wood frame construction. Simpson Stong Tie has been extremely generous in donating technical support and free products for the construction aspects of the projects.

University Professional Staff – Similar to many campuses, Cal Poly, San Luis Obispo is a thriving, growing campus. The ongoing capital programs on the university campus provide a unique, local opportunity for students to identify interesting, relevant projects with the assistance of the university capitol program professionals.

As a case study example, Cal Poly was recently gifted a large ocean pier structure on the California coast near the campus by the Unocal company. The university capital programs professional staff has made the pier and their professional expertise available for student projects. This mutually beneficial relationship has generated several capstone student projects on a real world structure that has added benefit for the university.

The Pro's and Con's

The benefits of industry integration in capstone projects are documented in prior literature. However, student led teaming with industry partners further enhances student learning in the following program outcomes identified in the 'a' through 'k' ABET criteria as follows:

(c) an ability to design a system ….within realistic constraints. As students explore and define the capstone project, they gain an understanding for the real life constraints such as budget, schedule, etc.
(e) an ability to identify, formulate, and solve engineering problems. Most engineering courses focus on solving the problem. The capstone experience is an ideal opportunity to allow students the experience of identifying and formulating the problem. When faculty determine the capstone project topic and industry partner, we diminish the student's opportunity to develop these critical engineering skills.
(g) an ability to communicate effectively. The process of engaging an industry partner in a capstone project requires the student to communicate effectively in a professional setting. When faculty take the lead in establishing the industry partnerships, the student misses a valuable learning opportunity.
(i) a recognition of the need for, and an ability to engage in life-long learning. The process of searching out and defining a capstone engineering problem exposes students to many engineering topics and ideas beyond their learning at the university. This process helps instill a recognition that learning continues after graduation.

Additional benefits of a student led teaming with industry partners include:

- Student leadership in identifying the capstone topic and industry partners helps to relieve the faculty from this time consuming task. A drawback of industry interaction in capstone projects that is well documented in the literature is the excessive amount of faculty time required to coordinate the projects and the industry partners. Since "finding design projects requires much planning and contact with potential sponsors"[1], allowing students to identify and develop their own project helps to reduce the excessive faculty workload.

- The student leadership model engenders increased interaction between students and the industry partners. The faculty member is no longer the middleman between the industry partners and the students. This allows for enhanced development of communications skills by the students and allows the faculty to act as mentors in guiding the interaction.

- The student led process unleashes their creativity in developing "meaningful and challenging projects" in a "real world environment"[3]. Many of the projects developed and implemented by students can have an amazing impact on society in the local area and worldwide. Case study examples of capstone projects in the ARCE department that have made a difference vary from teaching engineering principles to under-represented K-12 students in the local area to designing and building schools in developing countries worldwide.

There are also some challenges in implementing student led capstone projects including:

- The student led model does not generate significant funding for the university. While this model does typically generate some direct financial support for specific student projects, it is not focused on large scale funded research opportunities for faculty or the university.

- The approach requires a faculty group that is student focused and experienced with professional practice in order to successfully mentor the students during selection of project topics and industry partners.

- Not all students will successfully find an industry partner. In Architectural Engineering this is not a major concern since students have many opportunities to interact with practicing design professionals throughout the curriculum. However, for engineering programs where the curriculum is very theoretical this may be a significant concern.

Conclusion

The engineering profession needs graduates that possess a combination of strong technical, communication and leadership skills. The capstone project model currently used by the Architectural Engineering program at Cal Poly, San Luis Obispo relies on student, not faculty, leadership. This student led approach provides new opportunities for student development and learning beyond the traditional capstone project models reported in prior literature. It is hoped that this student led capstone project methodology described in this report may be of benefit to other departments and institutions.

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