A Process for Soliciting, Supporting, and Managing Industry-Sponsored Capstone Senior Design Projects

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This paper describes the process for solicitation, support, and management of fee-based industry projects for capstone senior design projects at Colorado State University. Six different kinds of projects are described with the focus on the solicitation and management of industry involvement on projects. Consistent with the literature, the student's capstone engineering experience is enhanced by industry involvement when advising and by providing support for project deliverables. Financial support is used for direct expenses related to deliverables of the project and by providing on-going support for the operation of the capstone program.

Introduction

Senior year mechanical engineering students focus on a year-long capstone design course to help them in the transition from college to an engineering career. This paper addresses a process for soliciting, supporting, and managing fee-based projects for capstone senior design projects. A conceptual overview of the capstone program and the different kinds of senior design projects are described. Industry sponsored projects are presented with processes for the solicitation, support, and management of the projects. The roles and responsibilities of the senior design faculty are described.

It is generally accepted in the research literature that industry involvement enhances the student experience in the capstone course[1, 2, 3]. The senior design project is a two-semester course sequence that partners senior-level engineering students with industry sponsors to tackle real-world issues in the form of a senior design project. It is recognized that securing and sustaining industry-sponsored projects, particularly for larger student cohorts (> 50 students) and twice a year new cohort starts, can be a challenge[1, 4, 5].

Capstone Overview

The senior design practicum experience is structured to cover two semesters with four credits each semester. Each semester, the course has lectures and student team meeting times built into the practicum experience. The lecture component has guest speakers, practical and refresher content (e.g., CFD, FEA, Cambridge Material Selector), report and presentation expectations, elevator pitch exercises, ethics content, and information about professional societies, to name a few topics. Student meeting time allows for blocks of time, specifically Tuesday and Thursday afternoons, for students and their sponsoring partners to meet on a regular basis, either virtually or at the partner location. Project space is provided for each project team on campus.

Team size is typically four students per project. Team member roles are divided into a team lead, financial lead, technical lead, and schedule lead. All team members are expected to take on specific technical responsibilities for engineering their aspects of project. Details including achieving milestones and critical path for the projects are broken down into a Gantt chart with expectations that the project is effectively managed. Project management is key when making sure the engineering reviews, purchasing of components and supplies, fabrication, assembly, testing, and the final demonstration are successfully accomplished.

The two-semester experience culminates with a final operational demonstration at Engineering Days (E-Days). E-Days is a long-standing university tradition that provides senior undergraduate students the opportunity to showcase their senior design projects to faculty, family, industry representatives, peers, and prospective students interested in exploring engineering.

Students gain practical engineering experience by working with industry partners to apply theory to practice using a structured design process. A structured design process conforms with industry best practices[1] using Quality Function Deployment (QFD). QFD (also known

as the House of Quality) is formally presented to the students in the sophomore year[6]. A structured design process with students involved with engaging competitions is taught throughout the freshman, sophomore, and junior year design courses.

At the senior year, student teams transform the "voice of the customer" into criteria, requirements, and constraints for comprehensive designs leading them to fabricate, specify, integrate, assemble, test, and to demonstrate their resultant solutions at E-Days

Partnerships between design teams and industry sponsors help students develop the skills they need to secure positions in the ever changing and diverse field of engineering. These collaborations create an opportunity to make a lasting impact in the lives of students as well as the companies benefiting from their hard work.

Kinds of Senior Design Projects

There are six kinds of projects that characterize senior design projects. The projects each have a sponsor, who is the customer, and a source for funding for the project.

The different kinds of projects are:
- Industry sponsored projects – These projects are fee-based projects at the typical level of $10,000 per project.
- Community projects – These projects are offered as a service-learning opportunity to someone in the community or a non-profit organization whose mission is benefiting the community in some direct way. The expenses are often underwritten by the senior design program.
- Competition projects – These projects are intercollegiate design competitions supported by a combination of fund raising by the students, funds from the senior design program, and funds from the department.
- Cooperative projects – These projects are usually between different engineering departments indicating the grading responsibility for the interdisciplinary team. The financial support comes from various sources including industry. If it is an industry sponsored project, it will follow the approach described in this paper.
- Faculty directed projects – These projects are supported by a faculty member wanting to financially support development of a piece of laboratory equipment or device typically related to their research.
- Entrepreneurial projects – Entrepreneurial projects are proposed by incoming senior engineering students to a college-wide program that funds the senior design project at a level of $5,000. The

students are mentored by an entrepreneurship faculty member and are required to concurrently take an entrepreneurship course in the College of Business.

Number of Projects Needed
The number of senior design projects needed for start of a fall semester cohort (i.e., normal cadence for students to complete their degree in the following spring semester) is 30-40 projects. Of these, two-thirds (2/3rd) of the projects are industry sponsored projects. There is also a spring semester cohort of students that will graduate in the fall semester. The spring start cohort of typically require 15-20 projects.

At any one time, there are 30-45 senior design projects running. With two cohorts of senior design courses, there are about 25-35 active industry sponsored senior design projects at any one time.

Industry Sponsored Projects

What is the process for engaging industry partners? The first step is to establish a trusted relationship that seeks to address real challenges of the companies. There are issues not immediately being addressed by the company, but the company might want to get some work started on an identified issue. These "pain points" can oftentimes be a good student design project when properly scoped.

Industry involvement in senior design projects provides many benefits to the lives and learning of the engineering students. However, getting the attention for collaborative interaction with industry can be a crowded space with lack of clarity and confusion caused by many on-campus interested parties. Industry partners seek interaction with the university in many ways including athletics (and now the student-athletes themselves with NIL opportunities), to engagement with the research enterprise, to gifts for facilities, faculty endowments, student scholarships, and other on campus interests.

To sort out some of the confusion, securing funding for a senior design project can either be a gift or treated as a sponsored project. Both of these approaches have their challenges due to lack of dollar magnitude and timing requirements to the academic calendar. It has been our experience that a fee-based approach reinforces the direct benefits[2] and value to back to the companies.

Some companies are concerned about retaining intellectual property (IP) on a project. Only about one quarter of the companies that financially sponsor a senior design project make this a requirement. For an industry sponsored senior design project, we ask the company to complete a sponsorship agreement that describes the project, the fee, semesters for project, the meeting

expectation for the sponsors involvement, IP assignment and NDA clauses, and expectation of deliverables.

All kinds of projects are pitched at the Industry Showcase Day at the start of the first semester of the senior design sequence. The sponsoring company prepares a pitch deck that promotes or pitches the project. The pitch deck contains three PowerPoint slides that introduces the company, the project, and any pertinent details such as expectations for the project activities take place at the company location or requiring NDA or IP limitations.

The students have choices with alternatives on the kinds of projects they want to work on for senior design. Along with timely instructor/student discussions about what is IP and what is an NDA, the student can make an informed decision as whether to pursue or not the project as one of their choices. It is important to have other projects available that do not have the requirement of IP and NDA limitations.

There are more projects available than students to assign to projects. This gives students multiple choices to meet their interests. Not all projects will proceed beyond the Industry Showcase. With plenty of projects available for students to choose, it lifts the level of the quality of the projects being pitched by the sponsors.

Solicitation Process

An important aspect of industry sponsorship is developing contacts and relationships with individuals in industry. Initially soliciting a project, the company does not have a project ready for senior design. The potential for projects needs to be developed through conversations and meetings with the faculty lead focused on industry sponsorships. This is a halftime activity taking place during the summer and fall/winter breaks.

Sales Funnel
Most of the industry sponsorships are developed through a solicitation process that involves "pull marketing" creating a sales funnel[7]. The four stages of the sales funnel are awareness, interest, decision, and action.

Emails to personal contacts are sent out to begin a conversation of about sponsoring a senior design project. At least three months of lead time is needed to solicit a project before the start of the semester. This requires discipline to keep on top of the contacts and follow-ups that will take place preceding the fall and spring cohorts.

Awareness Stage
Awareness stage is at the top of funnel and is the stage that casting a wide net where you make the targeted companies aware of the opportunities for projects with students and the university.

Approximately four times the number of companies at the top of funnel to yield enough projects. For example, the fall start semester will need 20 industry sponsored projects. It will take at least 70-80 initial company contacts to be made aware of a call for projects for senior design. The requests are sent via email to a specific company contact. Other useful contacts are serendipitous arising from working with the local startup incubator, meeting the chamber of commerce, learning of a technical problem issue on campus, or hearing from recent engineering graduate in the workplace.

Do not discount finding out about the possibilities for potential projects while being "out and about" in the community. It is surprising how projects materialize throughout the year by keeping "eyes and ears open" for qualified projects. Keep in mind companies initially contacted become candidates in the next iteration of the senior design sales funnel. It is important to keep building upon their awareness. Oftentimes they express some interest and are not ready to sponsor a project but are willing to be kept on the list for the next cohort.

Interest Stage
The interest stage is when you learn these potential "customers" are actively looking for a solution to some kind of technical issue they may be having. This leads to a call or virtual meeting, a coffee meeting, or a lunch where potential projects and potential sponsorship details are discussed.

Decision Stage
These initial meetings lead to the decision stage when the company identifies their "project champion" or lead contact that wants to pursue a project. There might be some back-and-forth conversations leading to more information needed to make the decision to pursue a project.

Action Stage
The action stage is when the target date for Industry Showcase is presented to the sponsor to prepare a pitch deck made up of three PowerPoint slides. About two weeks prior to the start of the first semester is the soft deadline for the pitch deck. There might be some discussion about the content of pitch deck. The primary purpose of the pitch deck is to stimulate student interest in the company and on the project. The project details should be about the problem rather than about what the solution could be. Senior design is a design experience after all.

Support and Management

The project pitch decks from all the sponsors are assembled into a "big pitch deck" that the students review in preparation to attending the Industry Showcase. The Industry Showcase is scheduled the first week of the first semester. It is held in one of the student center ballrooms on campus. Since the industry partners are venturing on campus, a concerted effort is made to make it a rewarding experience for them by providing them with a parking pass, directions to the venue, and food and refreshments.

Each project sponsor has a table to meet with the students at the Industry Showcase. The students and sponsors mingle for about two hours. The students ask questions about the project and about the company. The students provide their resumes to the company representative. The company representative takes note of those students that show a particular interest, understanding, or skills that might be particularly beneficial to the project.

At the conclusion of the event, each student provides their top five projects. Similarly, each company representative provides their top 5-7 students that they are interested in working with on the project.

Before the next week at the meeting of the senior design class, the faculty instructors put the students into teams based on feedback. The instructors match the top 1-3 projects based on the student's interest and top 3-5 students selected by the project champion representative. For the most part, students get placed on a team where the project is one of their top choices. Industry sponsors have a direct say in the students they would like to have on the project. It takes a good part of one day to convolve and assemble 30 project teams with four students on each project team. There is very little need for student placement adjustments after the teams are formed.

As the first semester proceeds, the company's project champion is expected to meet with the students every week or two on a regular basis. A faculty advisor and a graduate teaching assistant are assigned to each project team. As a team, they are expected to keep the faculty advisor and the industry project champion in the loop throughout the project. If at any time the students have concerns about the company (e.g., being difficult to contact and get a response), the faculty member that has the relationship with the industry sponsor gets involved as a relationship manager. Likewise, if the company has a concern, the faculty relationship manager engages the students about the issue.

Two faculty members are responsible for running the senior design program. The two cohorts of senior design courses are supported by these two faculty members and five teaching assistants. One faculty member is the instructor of record responsible for course operations and assignment of the grades in the course. The faculty member who is the relationship manager and responsible for lining up meaningful senior design projects uses the process described herein. It is important that the faculty member who lines up the projects have an "outward facing, value-based" perspective to meeting the needs of industry.

Summary

This paper described a process for soliciting, supporting, and managing industry-sponsored senior design projects. For more information on the Colorado State University Senior Design Program in mechanical engineering, visit: Senior Design Project - Department of Mechanical Engineering (colostate.edu)

Acknowledgements

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