

Capstone Projects that are Industry Sponsored, Interdisciplinary, and Include both Design and Build Tasks

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Abstract

Over the past decade, a great deal of attention has been placed on capstone design projects in engineering technology. This has come as a result of criticisms of education institutions for not meeting the needs of industry. To that end, nearly all institutions have adopted a capstone experience. Many have instituted projects that include both design and fabrication. Some have utilized industry-sponsored projects. A few have even implemented an interdisciplinary approach, by including several students from different majors on the design team. Of course, all of these enhancements are to better simulate the “real world” and thus, better prepare the students for the expectations of industry.

After years of working through all the barriers, the Department of Engineering Technology at the University of Dayton currently requires a senior design experience that encompasses all the mentioned enhancements. Teams of electronic, mechanical, manufacturing and industrial engineering technology students work with a company on a real project. The teams are given full responsibility from project definition and concept generation to the fabrication and testing of a device. The purpose of this paper is to share the experience and discuss some of the details on the implementation.

Introduction

The primary goal of an engineering technology program is the preparation of technically competent entry-level engineers for private industry. For the recent graduate, the transition from student to entry-level engineer can be a difficult bridge to cross. Industry managers have recognized this difficulty, and many companies have developed elaborate programs to aid the recent graduate in this transition

In the early 1990's, the public began to grumble about the poor student preparation for technical careers in industry. A great deal of criticism was thrust upon the technical schools and universities [4, 7]. In response, many initiatives were introduced to address the transition from textbook problems and real world situations [2, 3, 9, 14]. A great deal of dialog at technical society meetings, and accreditation boards, centered on application-oriented courses and incorporating business scenarios and communication into technical courses [1].

Capstone Courses

The most significant result of the discussions was that nearly all technical academic programs adopted a capstone course. These courses usually center on an unstructured design problem that requires the use of technical skills developed in the fundamental courses. Throughout the semester, students work through the several phases of a project, having periodic meetings with the instructor. The students must formulate objectives, generate conceptual solutions and work these preliminary ideas into a detailed design.

Academic institutions have implemented several different models for the capstone courses. Many of these experiences have been presented at technical society meetings. These models nearly form an evolution of capstone experiences over the past decade, and include:

Traditional, Single Student, Instructor Created Project

In a traditional capstone course, the instructor identifies a project at the beginning of the semester. Students are expected to work on an individual design. Class lectures focus on design methodology, decision making, and miscellaneous technical concepts [8]. At the end of the semester, students give an oral presentation of their solution and submit a formal design report along with technical drawings.

This traditional capstone course gives students experience with the solution of an open-ended problem, along with promoting professional written and oral communication. Students are given a taste of real world engineering design; but a classroom atmosphere is still present.

Capstone Projects that Incorporate Student Teams

In practice, teams are used for engineering projects for many reasons, including:

- ↳ To gain innovation from a variety of creative minds.
- ↳ To utilize people with different expertise and strengths
- ↳ To address a task in greater detail
- ↳ To serve as a check for each other, identifying potential errors and problems.

To better prepare the students for the work environment, a capstone project can be assigned to teams of students [10, 11].

Capstone Projects that Use Industrial Clients

Incorporating an industrial problem can enhance the capstone problem itself [6,15]. Student motivation is greatly improved by the challenge to solve a real problem. An air of seriousness immediately enters the project as additional stakeholders are brought into the experience. Knowing that someone is anxiously

awaiting the results of the project heighten student commitment .

Projects which involve the Fabrication of a Prototype

No doubt, a capstone course that produces a “paper design” is a valuable experience. However, this experience falls short of the atmosphere in a manufacturing firm. The question remains; “will it really work”? A capstone course can be expanded so the paper designs are further developed into actual working devices [13]. This builds confidence in the design for both the client and the students.

Projects which are Industry Sponsored, Interdisciplinary, and Include both Design and Build Tasks

In a true industrial setting, project teams are formed which contain personnel from several disciplines. However, organizing a common capstone for several academic majors is a difficult proposition, but one well worth accepting.

Implementing all Successful Models

The Engineering Technology Department at the University of Dayton has been able to surpass all hurdles and adopt a capstone project experience, which is industry sponsored, interdisciplinary, and includes both design and build tasks. The following sections describe the administration involved in the course.

Interdisciplinary Capstone

The most recent change was the institution of a common 2 credit hour, laboratory format, capstone project for all our engineering technology programs. Surprisingly, convincing faculty members that all disciplines should require an open-ended, free-formatted project was not a problem. The largest hurdle was to convince everyone that a single project would technically challenge students from several majors. Many faculty members were not willing to sacrifice technical rigor for the team building and management experience.

A buy-in process began with each discipline listing the activities that a student should complete in a senior project. Then, prospective projects were cited that had substantial technical depth in at least two traditional disciplines. Projects that seem to work best are product design improvements, manufacturing process automation, and product testing equipment. These projects tended to have process workflow, machine design and programming/control tasks.

After negotiation, appropriate, discipline-specific outcomes were listed. Then a common section of ECT 490 (electronics capstone), IET 490 (industrial capstone), MFG 490 (manufacturing capstone), MCT 490 (mechanical capstone) was placed

into the curriculum.

Soliciting Industry Clients

Obviously, the best projects have financial potential for the sponsoring company and significant benefits for the students. Attracting these ideal projects takes some investigation. For the sponsor, students can provide direct project engineering effort. Student teams may generate a variety of ideas with possible applicability far beyond the project's scope. For the student, the project must expose them to the technical demands, potential pitfalls, and professional expectations of practicing engineers. It also requires that the sponsoring organization assign a motivated individual to oversee and interact with the students throughout the project duration.

The key to gaining interest among sponsors is to establish contact with key individuals in local industry. Case studies of past projects are invaluable to illustrate potential. Every available means should be used to get the message to potential clients. Selling the program is a constant job. Brochures and samples of work should be kept handy at all times. Every luncheon, technical meeting, and plant visit provides an opportunity to get the message to a potential client. Currently, the University of Dayton charges the client a \$3000 fee for administrating the projects.

Forming Student Teams

Students work in project teams consisting of approximately five to seven members. The project teams are composed of students with varied, but complementary interests, backgrounds, experience and skills. The selection process used in determining members is based on expressed student interest, a student skills inventory, and an evaluation of the expertise needed to complete the project.

In practice, an engineering manager must make decisions to assure that projects are properly staffed and the work gets done on time and on budget. A message is sent to the students that the sponsoring companies do not see this as an academic exercise. They expect technically competent and working devices on time and on budget. Therefore, the project advisors must make decisions on staffing and project assignments.

Design and Build

All projects involve a solution of a problem. It is critical to instill confidence in the project sponsor. A prototype of the solution is the strongest manner to do this. Often, students fabricate parts in our machine shop. Depending on the details, they may "farm" the work to outside vendors. One-third of the current \$3000 fee is allocated to preparing a working model of the solution. Often the client wishes for a more extensive prototype and will be charged for the additional cost.

From an educational perspective, the prototype phase is invaluable. Designs never work exactly as intended. The debug phase is extremely beneficial and most often requires the greatest amount of technical insight. Additionally, student morale heightens as the solution they invented is built, and works! In one case, students talked their parents into driving seven hours to watch their prototype operate.

Organization

The organization, and roles of the stakeholders are as follows:

Project Advisors: The faculty member(s) assigned to the course are project advisors and serve as guides along with establishing performance standards. Since they are ultimately responsible for the projects, they must demand quality and timely work from the team. In effect, they treat the project team as if they were employed engineers.

Client Liaison Engineer: Each sponsoring company designates a contact engineer who serves as the project liaison. Companies usually request that frequent contact be made with this engineer regarding design decisions and project status.

Project Team Leader: Each student is asked whether they would or would not wish to be the leader. The leader is the main contact between the Team Members, Project Advisors and Client Liaison Engineer. The leader is responsible for organizing the group effort, setting schedules and maintaining schedules. Each team elects a team leader during the second week of the semester.

Each leader makes sure that the group is performing in an efficient and effective manner. Team leaders may make changes in task assignments to maintain the schedule of work. Due to the time needed to complete the administrative duties, team leaders are not expected to complete as much technical work as the team members. Probably the most significant job of the leader is to evaluate each team member at the end of the semester. The team leader will have a significant influence on the determination of the team member's final course grade.

Project Team Members: This is the position that most students hold. Project Team Members do the majority of the work. Project Team Members will wear many different "hats". They must be inventors, designers, purchasing personnel, schedulers, manufacturing personnel, quality engineers and test technicians.

While this project is a team effort, most of the tasks can be more

efficiently completed on an individual basis. Team meetings are used primarily for planning and for making critical decisions. It is expected that individuals accomplish the project tasks and present the results for team review.

Faculty Consultants: With several comprehensive and diverse projects, the technical ability of a project advisor is not adequate. Therefore, students are encouraged to utilize all engineering technology faculty members as technical consultants. A list of the specific areas of expertise for each faculty member is distributed.

Grading Policy

The grade in the capstone project course is based on team accomplishments as assessed by the project advisor(s) (50%) and the evaluation of the project sponsor (50%).

The performance of the team is evaluated by the project advisor(s) throughout the semester, and by the sponsor at the conclusion of the semester. The evaluation criteria are as follows:

- Effective in preparing and organizing work
- Aggressiveness; willingness to take initiative; self-starters
- Willingness to accept responsibility
- Quality and rigor of the technical effort
- Attention to design details (completeness)
- Attention to time constraints
- Sensitivity to client needs (cost, safety, etc.)
- Effectiveness of communication
- Overall project success

Assigning individual grades for a team project, in a fair manner, is always a difficult task. Some team members seem to take the project more seriously, or accomplish more than others. Those members that surpass expectations should be rewarded for their effort. To this end, peer evaluations are used to assign grades based on individual effort and the team performance. On a periodic basis, the team members evaluate the contributions and effort of each other. An autorating method is used to distribute the team grade [5]. Team leaders are also be consulted to assist in the determination of individual grades.

Required Project Deliverables:

Project Proposal: This is a written report that is submitted at the beginning of the semester that outlines the tasks that the team plans to accomplish during the semester along with a method of approach. A schedule and preliminary budget must be included in this report. It must be submitted to, and approved by, the sponsor.

Progress Memorandum: Approximately every two weeks, each team member will submit a progress memo, describing of the accomplishments of the previous two weeks, and the plans for the next two weeks. The team leader prepares a memo that addresses the issues for the entire team. This memo is forwarded to the client liaison engineer.

Oral Updates: Approximately every two weeks, a member from each team updates the entire class on the team's accomplishments of the previous two weeks, and the plans for the next two weeks. This is intended to be an informal, ten-minute talk and is rotated among team members.

Individual Portfolio: Each team member keeps a comprehensive record of project tasks. These tasks typically include conceptual sketches, design analysis, calculations, technical drawings, etc. This portfolio provides a record of the effort and accomplishments of each individual team member.

Team Portfolio: Materials from the individual portfolios are compiled and organized into a binder and submitted to the sponsor at the end of the term. This provides complete background information and reference materials for the project.

Formal Presentations: The team prepares a formal mid-term and final presentation to the sponsor. The mid-term presentation is used to solicit input and obtain guidance for the remainder of the term. The final presentation focuses on the results of the project. All members of the group are included in these presentations.

Final Report: The team submits a formal report at the completion of the term. This is a comprehensive report that documents the accomplishments throughout the semester.

After experimentation, the current policy is not to grade each individual deliverable. Instead, all documentation and presentations are accumulated and considered as an overall team grade is assigned based on the criteria listed in the previous section.

Summary

Capstone experiences have been widely conducted for over a decade. They have been evolving to better simulate the setting that students will experience after graduation. After years of reflection and adjusting, Engineering Technology at the University of Dayton has finally instituted projects that are industry sponsored, interdisciplinary, and include both design and build tasks

The course described in this paper is not a typical class. It is approached in the same manner that the instructor would approach a management positions in industry. There are only a few lectures, no formal homework, no tests and little planned learning. The one main goal for this experience is to produce an effective solution to the sponsor on time and on budget. A serious commitment is needed from all in order to succeed. However it can be infinitely rewarding and will not be an experience that the student will forget.

The results from the sponsors have been overwhelmingly positive. Most sponsors understand that the results they obtain may be flawed and incomplete. However, the student teams consistently exceed the expectations. Over the past two years, the average grade submitted by the sponsors was an A-.

The results from the students have been mixed. Formal student evaluations have very positive comments, such as:

- ☞ “The experience increased my knowledge of what it is like in a real world environment.”
- ☞ “Very good practical experience with a real customer and with real suppliers.”
- ☞ “I loved practicing and applying what I learned from previous courses.”
- ☞ “This experience makes me appreciate people and time skills much more.”
- ☞ “Great hands-on class that brought together teamwork and added responsibility in producing a prototype and pleasing a customer.”
- ☞ “The interaction of three different majors on my team increased my understanding.”

Suggestions for improvement consistently outnumber the positive comments. Some of the common remarks include:

- ☞ “Way too much work.”
- ☞ “Some projects are harder and more restrictive than others.”
- ☞ “Waiting on parts, which is out of our hands, makes life hard at the end of the semester.”
- ☞ “We should get more credits for this course.”
- ☞ “Bi-weekly memos and reports took too much time away from the real work.”
- ☞ “Students should not determine other student’s grades. Entire team should get the same grade.”
- ☞ “I don’t believe it is reasonable to expect a group of people to learn something that they had no experience with.”
- ☞ “I hate team projects.”

As with all courses, the administrative and technical aspects of this capstone experience need to be continually improved. Student comments are reviewed along with input from sponsors and industrial advisory committee members. Admitting that improvements can be made, there is justifiable reason to be pleased with the progress and satisfied with the success.

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