Capstone Design for Education and Industry - The Perspective of Industry Sponsors and Graduates

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INTRODUCTION

The ABET guidelines state "Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics and engineering sciences are applied to convert resources to meet a stated objective."[1] Guidelines for electrical engineering programs specify the number of credits of engineering topics where design integrates with engineering science throughout engineering courses. The electrical engineering section of the ABET Guidelines further encourages "a significant design experience" in the senior year[1].

The University of Idaho requires a two-semester senior level course sequence focusing entirely on design issues. Students develop skills in open-ended problem solving, identifying solution options, and maximizing resources under constraints. They are repeatedly exposed to the "design process" and are given numerous opportunities to develop written and oral communication skills. The projects require an element of original design and the demonstration of a working model, culminating in written and oral presentations of their design approach and results. Although no new engineering science concepts are formally presented in the senior design classes, we expect that the students not limit their design to knowledge acquired from previous courses. Students thus have an opportunity to learn how to gain new knowledge outside the classroom.

This senior design sequence has been utilized for several years. Author, R. Wall, describes the experience of sponsoring senior design projects from an industry perspective from 1984 through 1988 [2] before joining the University of Idaho faculty. Although the students are encouraged to complete course and instructor evaluations at the conclusion of each course, we recognize that many students lack the industrial experience to make quality assessments of the course value or to assess the ultimate contribution the senior design experience will make to their careers. We recently took the opportunity to further examine the value of industry sponsored senior design projects and look for suggestions to improve the course by means of a survey of the graduates and industries involved over the past five years. We acknowledge that this experience is not possible without industries who value the opportunity to contribute to higher education by direct involvement.

COURSE PHILOSOPHY

The capstone design course focuses on team building and cooperation. Students are introduced to the Demming philosophy. This approach contrasts capstone design experiences offered at other universities who use team competitions to motivate serious design effort[3,4]. From 18 years of industrial experience, these authors conclude that competition is defined and carried out by those who chart the corporate mission and define the product. Design is initiated when engineering moves the product definition to a set of functional specifications.

Because industry values employees with industrial experience, the traditional BSEE graduate must look for ways to generate this experience either through coop programs and/or the senior design experience. The two semester senior design sequence offered at the University of Idaho attempts to provide a credible industrial design experience by working with industry sponsors.

The first semester centers on an individual project and the second semester on a team project. For the team projects, the instructor identifies an industry sponsor, a support faculty and a group of interested students. During the initial team project identification phase, the instructor works with industry to establish expectations, limitations, and benefits. Involving industry with capstone design keeps the university in touch with industry needs, helps the students to understand their future role in the work force, and provides industry with a mechanism to integrate new technology with minimal investment. Industry provides money for hardware, consumable items, and difficult to obtain equipment needed for the project. We encourage representatives to interact directly with the students to provide guidance and some technical support.

COURSE CONTENT

The content of the senior design course is similar to that offered by many other universities[4]. During the first semester, students learn design methodology, IEEE format requirements for reports, proposal preparation, and design review participation. They learn the concepts of performance specifications and objective-based problem solving. To help students make the transition from "one question - one answer" type problems to a set of objectives with many possible solutions types of problems, we introduce the concepts of specifications, constraints, and objectives. This is accomplished by analyzing, modeling, constructing, and testing a liner power supply kit. During the next two semesters, students work on individual and team projects during the periods shown in Figures 1 and 2.

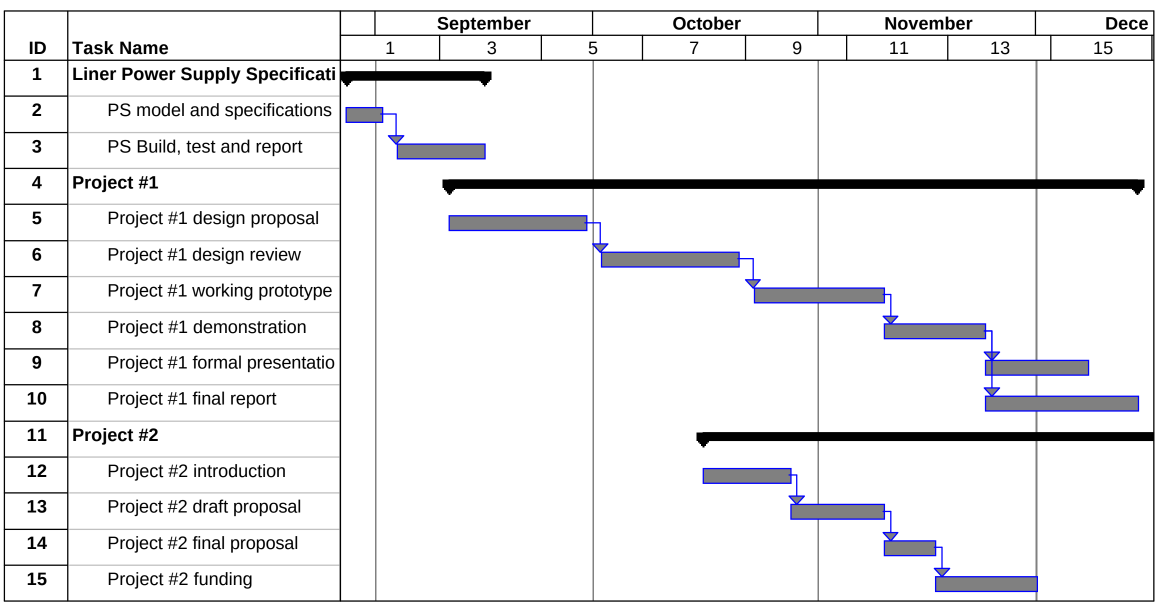

Figure 1. First semester design activities

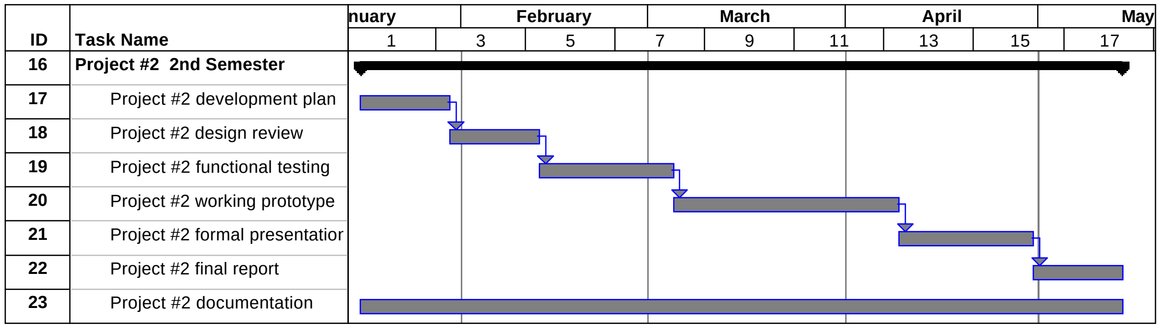

Figure 2. Second semester design activities

Figure 1 shows that students start their second project involving teams during the first semester before they have completed their individual projects. Around the eighth week of the first semester, industry sponsors make presentations to the class introducing the problems, providing background, discussing the desired solution, and giving constraints on the final solution. By the end of the first semester, a proposal for funded work is successfully negotiated with the sponsoring industry.

Industry advisors, who are the customers for the project, must be satisfied for the project to be considered successful. They interact with the students to provide guidance and additional education. Since this advisor is usually the most familiar with the problem, his guidance is critical in keeping students from running down blind alleys and wasting valuable time. We believed students and faculty highly value this interaction.

EXAMPLE PROJECT

A local utility recently began marketing an electric power service based upon photo-voltaic energy. This service offers an alternative to customers in the utility's service area who do not have economically feasible access to conventional electrical connection. The service consists of 120 VAC power provided by a bank of photo-voltaic panels, a standby propane electric generator, a bank of lead-acid storage batteries, and a DC to AC converter located in the utility-owned power hut. Customers expect the power supply to run small appliances (including a refrigerator), electric lighting and entertainment systems.

The utility wanted an instrumentation system which allows the customer to maximize the photo-voltaic energy and make life-style decisions based upon available sun and battery energy. The instrumentation system needed to be easily portable, to be self-powered in case of power failure for diagnostic purposes and to require minimum knowledge by the operator. This system had to be easily installed in existing as well as new construction and to meet extended operating temperature requirements.

The students developed a distributed processor instrumentation system which communicates between the energy supply hut and the customer's facility. Utilizing power line carrier technology eliminates the need for separate communications lines. The power line carrier communications allowed the utility customer display unit to be highly portable, requiring only an outlet to get both power and communications.

From our educational perspective, this project was highly desirable because it utilized all the students in the class on a single system. It required a wide range of electrical engineering knowledge, so all students made significant contributions to the success of the design effort. The class organized into three teams, each responsible for a particular portion of the project. This project's size affords a unique educational opportunity for the students to experience multi-team coordination as well as team design.

STUDENT FEEDBACK

Senior Design with industry involvement, characterizes the student experience since 1990. We randomly selected twenty of fifty-four students and surveyed the past three years graduates. We received fourteen responses to an open ended questionnaire. Several common themes reflect benefits the graduates received. Further, they made suggestions to improve the course.

The first question asked how well senior design taught the graduate the design process. Ten responded excellent, extremely well or good, while four said not very well or fairly good. One graduate suggested "a series of small projects to put students through the design process more times, thus reinforcing learned procedures." Another graduate suggested that the professor “walk the students through” an actual design first.

In the second question, graduates identified the skills they learned in senior design which helped them in industry. Two themes emerged from over half the respondents: team work and communication/presentation/report writing. As one alumni put it "improved on the dealing with other people, to be more patient..." Three other areas were also mentioned by at least three graduates: budgeting, critical thinking and time management.

A multi part question then dealt with how to improve equipment/supplies, teaching style, subject material, and organization. To improve equipment, graduates encourage the use of new technology, more computers, and equipment manuals and guides. Half the respondents liked the teaching style and felt more time with the instructor or instructors would benefit instruction methods. "Always meet in classroom on scheduled days, and set and maintain project due dates, review dates, and related deadlines. This will be exactly how real projects work." Three felt the subject material was excellent and two suggested shorter, more concrete, realistic problems. Finally, half the students recommended more required meetings and deadlines to improve the organization. One suggested a video of actual presentations to improve the course.

Graduates were asked how industry involvement affected the quality of the design experience. Half the graduates indicated that it made it more real. One respondent said "It made the quality more realistic as the customer requirements were always shifting which seems to be how it is in industry." Additionally, three noted the quality was better with hands on experience. Two alumni also said understanding customer needs made their design experience better. It is important to also note that two of the former students did not have involvement with industry projects.

The last question inquired about the type of project the graduates felt best suits senior design. Again, half endorsed a project that involved several areas of electrical engineering. Additionally, four identified a real project which would meet customer needs since "the best project is the one that comes from an actual company. This way when the project is done, the student can feel good about it." Three also supported the individual then team project approach. The final important recommendation is to "increase interaction with the industry partners at the student level."

INDUSTRY SPONSOR FEEDBACK

Industry sponsored eight projects over the last five years. Success of projects were not critical to the mission of any of the companies. Two of the representatives of industry sponsors have Ph. D.’s and the remaining BSEE. All have some supervisory as well as technical responsibilities in their work assignments. The direct cost to the companies for parts and supplies ranged from $400 to $6000. Surveys, consisting of five open ended questions, were sent to all eight sponsors and responses were received from seven of them. Although the particulars of the responses varied, common threads were easily identified. The purpose of the survey was to solicit ways of improving the senior design experience from the industry's perspective. The following paragraphs discuss our observations both in what we found as well what we didn't find.

When the industries were asked why they were motivated to sponsor the project, all respondents indicated an interest in becoming involved with higher education. Other strong motivations included opportunities to identify future employees, investigations for proof of concept, and expanding the education of the industry sponsors themselves.

The second question asked the sponsors to discuss the results of the student work. A majority of the respondents stated that they obtained valuable knowledge from working with the students and/or from the student's reports. Over half the responses claimed that the student projects influenced designs of other products. Two sponsors cited hiring students as a result. Only one student project resulted in an end product in use with only minimal additional effort by the sponsor.

Thirdly, we asked what expectations the sponsors had for future senior design projects. We wanted to identify the types of problems that give industry the most value for their involvement. The only recurring theme was that the projects must be limited in scope and must be well defined. Contrary to our expectations, none of the respondents cited any difficulty with the financial or time commitments needed to support the projects.

Next, the sponsors were asked for suggestions to improve the industry sponsored senior design experience. Most replied that better communications is needed between the design teams and the industry advisors. They want better tracking of student progress and more interaction with the students. Also cited was a desire to become involved with interdisciplinary design projects.

Finally, we solicited input as to what types of projects they felt were appropriate for this design experience. The industry sponsors stated that projects should not be mission critical, but rather well defined and within the available time, test equipment, and knowledge base resources of both students and faculty.

CONCLUSIONS

A capstone design sequence is described which includes industry sponsored teams projects for a major design experience. Surveys of graduates and industrial sponsors involved over the past five years provides feedback to reinforce our commitment to what we do correctly and guidance as to what can be done to improve this educational experience. The number one recommendation from both industry and graduates was improved communications. Industry wants more time with students and students want more time with faculty and industry advisors. These comments from the graduates surprised us since this contradicted comments on the student's end-of-course evaluations.

The second most significant recommendation was the request from both industry and students for more time management requirements. Graduates said that students should be held accountable for deadlines and want scheduled meetings with industry advisors and faculty.

Industries that sponsor senior design projects want to become involved with higher education. They do not consider their involvement a donation but are looking for a return on their time and money investments. Industry likes projects that are educational for them as well as the students. However, these projects should not be mission critical.

Most of the students felt that the two semester sequence did teach the design process. The management and communications skills they learned were most helpful to them in industry. They felt that the industry sponsored projects improved the quality of their education.

REFERENCES

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BIOGRAPHY

Richard W. Wall received his BSEE in 1968 from the Pennsylvania State University and his MSEE and Ph.D. from the University of Idaho in 1980 and 1989 respectively. He was employed by Idaho Power Company for 18 years as a development engineer in the communications, relaying and R&D departments. In 1989, he joined the Department of Electrical Engineering at the University of Idaho as an assistant professor where he teaches courses in industrial control and instrumentation. His research interests include networking distributed power system protection systems.

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