

# Bridging Capstone Design with Industry Needs through Communication, Training and Involvement\*

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The desired overall outcome for any university Capstone design project is for the students to have completed a successful project and to have had a relevant learning experience. Within this expectation, however, a Capstone design project completed in conjunction with an industry sponsor will inevitably generate certain additional expectations from both the industry sponsor and academia. At Brigham Young University there have been a number of teaching and coaching aids used to prepare both the students and the project sponsors so that the eventual outcome is satisfactory to all. These learning tools create opportunities for success by bridging Capstone design requirements and educational objectives with industry's willingness to partner with academia, creating a better understanding of the learning process and requiring the completion of a professional, finished project. This paper describes how to create a culture of communication between industry sponsors and student teams, explores the need for training for both liaison engineers and Capstone faculty coaches, and discusses lessons learned regarding the need for involvement from both industry and academia.

**Keywords:** capstone; industry sponsor; liaison engineer; faculty coach

## 1. Introduction

In 1990, Brigham Young University's Ira A. Fulton College of Engineering and Technology implemented a new course designed specifically to better prepare senior engineering students for the practice of professional engineering. Created by professors Robert H. Todd, Carl D. Sorenson and Spencer P. Magleby, the two semester class, entitled *Integrated Product and Process Design* (referred to more commonly as MEEN 475 and 476, or simply, Capstone), taught students the necessities of working together in multidisciplinary teams to create a design and build a project for an industry sponsor [1].

From the course's initial inception, Drs. Todd, Sorenson and Magleby envisioned that the student teams would work closely with their industry sponsor in completing an assigned project. It was important that both the needs of the students and the needs of the sponsor would be fulfilled in order to make the partnership unique and effective for both. We found that having the students learn and use a structured design facilitates independent, hands-on learning while at the same time helps the project's sponsor to recognize the importance of the students' learning process. Capstone creates an effective and useful environment for bringing industry and academia together to meet the needs of both.

This paper will first discuss the purposes of Capstone in relation to industry needs and expectations. Second, it will share the importance of creating a culture of communication when managing the relationship between industry sponsors and student teams. Third, it will present how BYU's Capstone

program trains both the faculty coach and the sponsor's liaison engineer so that each will come into the project with similar expectations. Fourth, the paper will discuss the importance of student and industry involvement, setting guidelines for participation. And last, it will conclude with a brief description of lessons learned over the past 20 plus years through 641 completed projects.

## 2. Capstone background

The purpose of Capstone is to prepare students for the practice of engineering by allowing them to put into practice what they have learned through previous educational experiences. The BYU Capstone approach outlines the outcomes for its two-semester course MEEN 475 and MEEN 476 in BYU's *Product and Process Development Guide and Record Book* (referred simply by the students and staff as the *Guidebook*) [2] as follows:

*The overall objective of Capstone is to help each student become a successful, practicing professional who can make a positive difference in the world. To achieve this, each student is expected to learn to:*

1. Understand and apply a structured design process to complete a design project that adds real value to a project sponsor.
2. Understand and apply principles of project management and scheduling to ensure that the right work is accomplished at the right time.
3. Integrate the knowledge and skills developed over the course of prior education and experience to achieve high-quality engineering designs that meet customer needs.
4. Participate synergistically as a team member,

whether leading or following, in order to help the team succeed at the highest level.

5. Grow personally and professionally, taking the responsibility to learn and work independently; seeking outside help, advice, and feedback as needed to complete the design project.
6. Work hard on a challenging project, in spite of the difficulties that will arise, and couple that work with faith to accomplish an outstanding solution.

The Capstone program at BYU requires senior students from mechanical engineering and manufacturing engineering technology to complete this two semester course. Senior students from other engineering disciplines within the college of engineering and technology are also welcome to sign up for the two semester course as well, since many projects include electrical, chemical and other components. Students work in teams of five or six and usually are combined with students from engineering disciplines different from themselves. This allows for the students to interact with students with different skills but also prepares them better for industry, as they will regularly work with various engineering disciplines.

In addition to helping students become successful engineers, another objective of Capstone is to encourage students to better understand the project sponsor's needs and expectations. Having a better understanding of what industry expects helps both the students and the sponsor's liaison engineer develop a plan for completing the project *and* the two semester course. The goal is that there will be no "surprises" from either party as a result of regular communication and involvement.

BYU conducted a survey in 1993 in an attempt to better understand industry's needs as they relate to newly graduated engineering students. Despite the age of the survey, the data collected is still relevant due to the fact that a stigma still exists regarding academia's inability to prepare students for industry practice. Industry responses regarding weaknesses in new engineering graduates included:

- Technical arrogance.
- No understanding of manufacturing processes.
- A desire for complicated and/or high tech solutions.
- Lack of design capability or creativity.
- Lack of appreciation for considering alternatives.
- No knowledge of value engineering.
- Lack of appreciation for variation.
- All wanting to be analysts.
- Poor perception of the engineering process.
- Narrow view of engineering and related disciplines.
- Not wanting to get their hands dirty.
- Consider manufacturing work as boring.
- No understanding of the quality process.

- Weak communication skills.
- Little skill or experience working in teams.
- Being taught to work as individuals.

BYU's Capstone program works closely with project sponsors to address these needs. Clearly, when an industry sponsor spends \$20,000 on an educational grant to sponsor a project they have certain expectations. Not only do they expect to receive a completed project which includes a well-documented design, a written report and a functional prototype, but they also expect that the project will be a collaborative effort that will better prepare engineering students for their first job.

In collaborative efforts this year with the National University of Singapore, Pennsylvania State University and the University of Connecticut, BYU's engineering students are learning about globalization as well as the effects of being interdependent with others to complete a project. The sponsors for these projects would like to have their traditional needs and expectations met but also want the student teams to collaborate with teams at other universities and within industry to create a modern approach to problem solving.

In order to manage the needs of both academia and industry it is important to first recognize the stakeholders in Capstone. They include students, faculty, industry, academic administrators and others [3]. BYU's Capstone program is designed to address these stakeholder needs and expectations; this paper will demonstrate in the following sections how this is accomplished.

It will be helpful for readers to note that documentation used in the BYU Capstone course (and referenced in this paper) and examples of completed projects are found on the website [capstone.byu.edu](http://capstone.byu.edu). This website is also used to regularly recruit new projects from current and potential sponsors through a simple on-line submittal process.

### 3. Managing industry sponsors and student teams

In an effort to bridge the needs of industry sponsors and academia, it is important to closely and effectively manage expectations. Since regular communication is essential for any successful project, this section will address ways to manage those needs and expectations.

#### 3.1 Managing industry sponsors

Prior to accepting a project proposal from a potential industry sponsor it is important to spend time setting expectations up front before final approval is granted for a project with the sponsor. This includes giving them an introduction to the Capstone pro-

gram and the expected outcomes, including a copy of the *Liaison Engineer Guide* [4]. In our experience the more information given up front to the sponsor the better they are prepared for deliverables, presentations and challenges throughout the course of the project and the two semester class.

Regular communication with the sponsors via personal visits and follow up telephone calls is the best way to know if their needs and expectations are being met. Besides regular communication with the liaison engineer by the faculty coach, BYU also has a full time External Relations Manager whose job it is not only to help recruit appropriately sponsored projects, but also to follow up with personal visits throughout the project to monitor progress. The External Relations Manager establishes a relationship with the sponsors that can be invaluable to help work through problems that either the faculty coach, Capstone team or industry liaison engineer find difficult to resolve.

Follow up surveys are sent to industry sponsors three times throughout the year. The first survey is sent in October for initial input. This survey sends a message to the sponsor that BYU's Capstone administrators are dedicated to the success of the project and want feedback. The second survey is sent after the first semester has ended and second semester has begun. At this time the sponsors will have seen the preliminary design presentations at the midway point in the project and have a better understanding of where the team is heading. Finally, after the school year has ended one final survey is sent to gather information on the entire project. These three surveys provide invaluable feedback which allow for necessary course adjustments prior to the beginning of the following school year.

### 3.2 Managing student teams

Besides setting expectations with the industry sponsor, liaison engineer, and the faculty coach, it is important to establish expectations up front with the students. Once the students understand the importance of taking the Capstone course and the investment made by the university and industry on their behalf, they can work more effectively to accomplish the project successfully.

There are a number of action items required of students at BYU to help manage and strengthen their communication with the industry sponsor. Students attend one-hour weekly Capstone class lectures. These lectures include topics such as identifying and interpreting customer needs, writing functional specifications, concept generation, prototyping, documentation, and economic analysis. Student project teams are also required to send a weekly report to the sponsor listing their accom-

plishments for the past week and planned accomplishments for the coming week. Student teams communicate weekly with the liaison engineer in a telephone or web based video conference. It is during this meeting that they ask questions, receive answers and gain approvals. They also receive real time feedback on their accomplishments and planned accomplishments. These communications are documented in the students' record portion of the *Guidebook*. Additionally, the teams give two design reviews each semester to the course instructors. These reviews afford them a safe learning environment in which to share their work and receive feedback on their progress prior to presenting more formally to the industry sponsor and liaison engineer at the end of each semester. The results of these efforts help the students bridge the communication gap that might otherwise exist between academia and industry.

## 4. Faculty coach and liaison engineer training

One of the most important ways to bridge Capstone design with industry is to clarify the expectations of the faculty coach and liaison engineer and take the time to train them on what Capstone is all about. Making sure that all of the participants understand their responsibilities opens the door to better communication and the opportunity for a successful project.

### 4.1 Liaison engineer training

When the liaison engineer representing the industry sponsor understands their role in a successful project, the students are better able to realize the design process. At BYU we use a *Liaison Engineer Guide*, which is a simple 8 page training guide to help the new liaison engineer in their interactions with the team. This guide includes an overview of Capstone to help the liaison engineer become more familiar with how Capstone works. It also creates an opportunity to establish expectations up front that will act as a guideline when challenges arise during the course of the project and the class.

There is a section in this guide that describes eleven specific accomplishments that students are expected to achieve during the course. Some of these expectations include engaging in regular communication with the liaison engineer, generating and selecting design concepts, developing proof of concept hardware, participating in design reviews and formally presenting their work with final documentation and a completed working prototype.

The *Liaison Engineer Guide* focuses on four main areas, including monitoring progress, maintaining

team relationships, evaluating project results and providing regular and honest feedback.

Responsibilities are summarized in the conclusion, which is titled “Keys to Success as a Liaison Engineer”. It is here that five suggestions are given to help the liaison engineer in their role as an important part of the Capstone course. They include:

1. Support the design process as taught in the class. You may want to add your own strengths, but please don’t take off on an extremely different approach.
2. Clearly communicate your perception of how the team is progressing with the faculty coach and team. If you are unhappy, let them know about it. If you feel like the team needs to hear some specific comments, tell the coach.
3. Develop an expectation that the project will be successfully completed on time.
4. Make time available for your team. Communicate with the coach and team weekly.
5. Let the team know you are counting on their work. Explain the impact that the project will have on the company.

#### 4.2 Faculty coach training

On average there are 30 Capstone teams at BYU each year with typically half of the coaches (referred to as part-time faculty coaches) coming from industry. The balance consists of full-time faculty from various departments on campus. Coaches are given a project that most closely fits their professional background, although this is not always guaranteed due to the variety of industry sponsors and projects [5]. Taking the time to properly train the faculty coach is an important aspect of the Capstone program as it relates to meeting the needs of the stakeholders. To accommodate this training BYU has developed a pamphlet titled the *Faculty Coach Guide* [6]. The following section will give a brief description of what can be found in the *Faculty Coach Guide*.

#### 4.3 Faculty coach guide

After a brief introduction, the guide begins by explaining the expectations required of a faculty coach. Some of these include regular communication with the sponsor’s liaison engineer, becoming familiar with the Capstone policies and procedures, attending class lectures and sitting with the coach’s assigned student team, attending weekly team meetings and participating in faculty coach training meetings held periodically throughout the semester.

A critical component to becoming an effective coach is creating and maintaining a relationship with the liaison engineer. Meeting the liaison engineer immediately following the project assignment and prior to the teams being formed at the beginning of the school year creates an opportunity to address

potential concerns of both parties. Thereafter, regular communication is the key to resolving issues that occur throughout the process of working on a real-life engineering project, regardless of whether it is completed in-house or by a student team. Oftentimes the scope of the original project will tend to “creep” so that it includes more than the students can accomplish given their limited two semesters. The opposite can also happen in which the scope is narrowed too much and the students are not challenged. Regular communication between the faculty coach and liaison engineer benefits both the industry sponsor and the students.

The *Faculty Coach Guide* concludes with a section that outlines the roadmap for success. These suggestions include: choose a team leader early, learn the Capstone design process, learn and promote the Capstone course outcomes, develop and maintain an effective team, communicate regularly with the sponsor and team, provide regular feedback, *be* a coach, encourage your team to write often, understand that each team and project is different, be available, seek help, have fun.

Another way to manage the expectations of the faculty coach is to hold regular coach meetings, which includes following a formal agenda. The BYU Capstone program holds three coaches’ meetings each semester. The first coaches’ meeting of the school year, held prior to the first day of class, is designed to be an introduction to Capstone and to promote understanding of responsibilities as a faculty coach. Setting these expectations at the beginning of the school year is critical prior to receiving the project and working with student teams.

## 5. Establishing guidelines for student and industry involvement

It is important to establish guidelines for participation at the beginning of the project for both the student and industry sponsor. Having an understanding of each other’s involvement from day one helps ensure a more open line of communication and can prevent students from assuming the worst when a problem arises. The *Product and Process Development Guide and Record book* or *Guidebook*, given to students their first day of class, gives them the required expectations for the two-semester course and their work on the project.

### 5.1 Student involvement

For the students there are weekly team progress reports that are emailed to sponsors which include weekly accomplishments and planned accomplishments. A weekly telephone or video conference is also strongly encouraged between the student team

and liaison engineer. Other expectations of the students include regular student design reviews and formal presentation “practice runs”; both are held with the instructors present to offer critical feedback. The instructors also formally review and grade the team’s final design and prototype hardware. These formal expectations for the students help resolve concerns sponsors may have with regard to students’ understanding of their project requirements and needs.

The bridge between academia and industry is strengthened when students understand their involvement is critical as it relates to not only their grade in the course but also their industry project sponsor’s needs.

### 5.2 Industry involvement

It has been our experience that excellent communication and involvement from industry sponsors creates an environment in which student teams feel encouraged and exert a great amount of time and energy not only to receive a good grade, but to please the sponsor as well. The reverse is also true. When the industry sponsor does not have enough time to communicate regularly and give needed feedback, the team becomes discouraged and the project outcomes may become weakened as a result. Industry sponsor participation in the formal design presentations, weekly telephone/video conferences and feedback on weekly progress reports are important aspects of bridging the needs of both industry and the students learning experience.

## 6. Lessons learned

The Capstone learning experience is unique and often new to students. They are accustomed to solving theory based problems that are not open-ended and have seldom worked in a team environment. With Capstone they have the new challenge of working on a “real world” engineering problem. The students are also required to work in multidisciplinary teams and must learn team dynamics to accomplish a successful project [7]. We have learned that working on a Capstone project can be a very valuable aid in preparing students for what to expect in industry once they leave school.

Evaluation and assessment of a project can also be very challenging and difficult for the instructors, students and industry sponsor. Each project is unique and has its own set of expectations depending upon the industry sponsor and the intrinsic needs of the project. In order to facilitate success with this challenge, students are taught a structured design process and are graded based on their individual learning of the course material, their team grade, and their individual contribution to

the team on the project. Time is also spent educating industry sponsors on the evaluation process. Although there is much subjectivity to evaluation and assessment in a Capstone design course by both the industry sponsor and students, we have learned that when the expected outcomes are outlined and properly presented, both are more likely to be satisfied with the results.

## 7. Conclusion and recommendations

We have addressed the purposes of Capstone in relation to industry needs and expectations and shared the importance of creating a culture of communication when managing an industry sponsor as well as student teams. This paper also discussed how BYU’s Capstone program seeks to effectively train both the faculty coach and the sponsor’s liaison engineer, with specific training guides, so that each begins the project with similar expectations as well as an understanding of the importance of student and industry involvement.

We pointed to a number of industry perceived weaknesses of new engineering graduates and have used the Capstone course to individually address them throughout the two semester course. For example, a couple of these weaknesses included “little skill or experience working in teams” and “being taught to work as individuals”. Placing the students into teams for the full two semesters and teaching them the importance of teamwork address both of these weaknesses. Each perceived weakness has been addressed similarly through lectures in class, professional development seminars, case studies, project reviews, team presentations, mentoring and weekly communication with the sponsor.

Partnering with industry is a significant way to prepare engineering students for the practice of engineering in industry. Bridging Capstone design with industry needs allows students the opportunity to apply knowledge rather than just learn in a classroom environment [8]. They learn how to meet a customer’s needs while using a design process and applying that knowledge to a real-life industry sponsored project.

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