

# Training Faculty to Coach Capstone Design Teams\*

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*During senior capstone experiences, student teams are often given a faculty advisor to teach and assist them. Our experience has shown that using the traditional student/faculty teaching model is not an efficient or effective approach to the student learning of design and team processes. The objective of the paper is to show that successful learning experiences for capstone design teams require faculty to shift their role from a traditional lecture or consulting role to a coaching role. Research into key indicators of engineering design team success related to coaching focused on team observations, individual and team interviews, and individual team member and coach surveys. Results shows that a successful coaching role encompasses three main responsibilities: mentor, mediator and manager. Specific expectations and activities that a coach should fulfill to aid in the success of capstone teams can be established.*

## INTRODUCTION

TRADITIONALLY, undergraduate engineering students culminate their educational experience with a senior project. Although often given an advisor to assist them, some students fail to achieve the competency goals of these educational programs. In our experiences, the traditional student/faculty teaching model is not an efficient or effective approach to the student learning of design and team processes that is needed to be successful in industry.

The objective of this paper is to show that successful learning experiences for capstone design teams require faculty to shift their role from a traditional lecture or consulting role to a coaching role. Our research shows that the coaching role is essential to the success of the capstone educational experience, both in terms of learning and project results. In addition, there are key indicators of team success that coaches can use to evaluate the progress of their team, and properly focused training can increase the ability of faculty to effectively coach successful capstone design teams.

This paper first provides background and definitions of the capstone program at Brigham Young University, as well as related research done both at BYU and elsewhere. Next, results from our research on design team success factors are discussed, including key indicators of successful teams. A capstone coach's role is then defined, followed by the results of some of our coach training experiences. Finally, the need for further development of faculty training is addressed.

## BACKGROUND

The Capstone program at BYU is designed to be a unique two-semester educational experience for students in their 4<sup>th</sup> year of studies in Mechanical and Manufacturing Engineering, Industrial Design and other technical majors [1]. Currently, this course is the first comprehensive introduction to both design and team processes that students receive. The first three weeks of the course are devoted to teaching design and team processes by way of a common design experience. The early design process followed in the Capstone program is largely taken from *Product Design and Development* by Ulrich and Eppinger. Following this exercise, students are placed in 5 or 6 person teams [2] to work on an industrially sponsored design-and-build project. Each team is assigned a faculty coach who is responsible for training of the team, evaluation of team performance and management of scope issues with the sponsor. Each project has a liaison engineer assigned from the sponsoring company. All teams are supervised by a group of faculty instructors/directors. These instructors conduct weekly lecture, weekly lab, and periodic design reviews. During the lecture, students are taught the design process, team processes, and documentation approaches. During the labs, students work with the instructors and coaches to apply the design process to their project. Over 220 projects have been completed at BYU during the past 9 years.

Success for the Capstone experience is defined in three areas: learning and application of design processes, understanding of and skill in team processes, and successful result of the project itself. We believe that successful project results

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reinforce the process learning and build the confidence necessary to be successful at later projects in industry. Our goal to achieve the desired learning and project successes have led to research in a number of areas related to team-based design.

Broad areas of investigation have included team composition, matching teams to projects, defining success indicators, assessing team progress, and defining interactions of teams and design tools. Our results have led us to believe that there is something significant about team composition, but it is difficult to get a good model. A more immediately beneficial area has proven to be studies on what effects environmental factors, such as coaching, project relationship and instruction, can have on team success.

While there is extensive literature on general team dynamics, only a few collaborative studies have been documented which incorporate both an expert in team dynamics and an expert in engineering design [3–5]. These unique studies enable us to determine what teamwork means in an engineering context.

From our research, we have established key indicators of engineering design team success. This was done by way of a progressive interactive study. First, the criteria for success were defined. This was followed by an assessment of each team according to this definition [3]. Next, we looked for team member and coach behaviors that correlated with team success. From this we identified critical behaviors as key indicators for success. Our research further shows that these key indicators can be used by coaches to enhance the success of capstone design teams.

## RESEARCH METHOD AND RESULTS

In order to establish an effective method for the research into key indicators of engineering design team success, several methods were considered. Based on preliminary observations, the decision was made to collect data through a sequence of progressive studies [3]. These progressive studies included team observations, individual and team interviews, and individual team member and coach surveys. This enabled us to gain a better understanding of what factors are important to the success of design teams and ultimately to focus on specific key indicators.

Each progressive study included not only quantitative survey data, but also qualitative data, such as general conversations, interviews and team observations. While the quantitative data provided statistically significant findings, the qualitative data added reasoning and justification to the given quantitative responses, as well as additional insights into what makes an interdisciplinary engineering design team successful.

The following is a discussion of the final results of the research. The results have been put into three categories: *indicators* of successful design

teams, *activities* of successful design teams, and *additional findings* on successful design teams.

### *Indicators of successful design teams*

Analysis of the quantitative survey data, along with supportive qualitative data, resulted in identifying the top four indicators that had the greatest influence on the success (as previously defined) of design teams. The top four key indicators of successful design teams were derived from statistically significant quantitative survey data and each have a positive correlation with success. They are as follows:

1. Effective relationship with the sponsor's liaison engineer.
2. Coach's awareness and concern of team success.
3. Coach's ability to assist in both team and design processes.
4. Students' ability to work effectively as a team.

While the second and third ranked indicator are directly attributed to the coaching role, the first and the fourth indicator can also be linked to a coach's ability to properly perform the coaching role.

### *Activities of successful design teams*

Beyond the quantitative data, an extensive amount of qualitative data from interviews and observations has also been gathered to enhance the meaning of the quantitative results. From this qualitative data, the following key *activities* were found to exist consistently among successful capstone teams; each of these will be discussed in more detail:

1. Initial team process discussion.
2. Periodic team self-assessments.
3. Preparation for and reflection on design reviews.

Initial team process discussions include discussing and documenting such issues as decision-making processes, conflict resolution, establishing roles and expectations, running team meetings, performing periodic team self-assessments and maintaining sponsor contact. Along with this discussion, students became more acquainted with each other and began to identify individual strengths and weaknesses among their team members. With this knowledge and established processes, team members tended to work better as a team. It is important to note that this discussion resulted in a working document of the discussed and then established team processes that provided a reference point for future discussions. Decisions made at this initial team meeting simply gave them a foundation to work from. Successful teams would reflect on their initial team process discussion and document throughout the year, making changes as needed.

This leads us to the next key activity of successful teams: periodic self-assessment reviews. These reviews, typically done with the assistance of the

coach, would reflect on both team processes, as established in their initial team process discussion, as well as the design process, including an overall assessment of their project progress. This not only caused team members to reflect on the team's progress to date, but also to think more clearly about the direction their team was going. Such self-assessments helped the team better establish how the team was performing relative to both their team and project goals.

A third key activity of a successful design team was the ability to prepare for and reflect on design reviews. When a team regularly performed self-assessments, periodic reviews were more useful. Successful teams compared the external assessment with their own assessment, and more effectively used the feedback and suggestions they received from the reviewer. Again, particularly early on, coaches played a large part in helping teams prepare for and reflect on periodic reviews.

#### *Additional findings on successful design teams*

In addition to the student survey and interviews, the coaches of the teams were also surveyed and interviewed. Based on this data, three additional findings also support the need for an effective coach:

1. Successful teams demonstrated unified vision between team members and their coach.
2. Successful teams were able to manage less involved team members.
3. An external reviewer cannot effectively substitute for a coach.

These three findings will be discussed. First, in looking at a coach's response on how his or her team was performing, the successful teams' coaches tended to respond closer to the team's average self-assessments than the less successful teams' coaches. This result may be directly related to the fact that successful teams' coaches tended to be more involved and aware of their team's strengths and weaknesses than the less successful teams' coaches. Also, because the coach is more involved, the team may tend to directly reflect the coach's opinion of how the team is performing. In either case, having a unified vision between team members and their coach was an indicator of team success.

Second, typically there are one or more persons on each team which tend to do less than other team members. This may be due to various factors, such as a team member's lack of experience, lack of time, or even an inability to effectively communicate and work with the other team members. Successful teams, often with the assistance of their coach, were able to identify such problems and work with the less involved team member, taking advantage of and valuing what he or she could do and dealing with what he or she was not able to do.

Third, although the main objective of a reviewer is to guide a team toward success, our research

shows that this alone does not indicate success. In fact, the quality of the review is not even critical to the team's success. The critical issue here is that a team uses the reviewer's comments as an external resource to question their own self-assessment and then make a team decision as to how to proceed, including what reviewer suggestions they will integrate into their plan and what they will not. Again, this is frequently done with the assistance of the coach.

The results of our research, including key indicators, key activities and additional findings, demonstrate the critical nature of the coaching role. Each indicator, activity, and additional finding relates either directly or indirectly back to the coaching role. When the coach has and uses appropriate coaching skills and understands the basic design and team processes, the team is more likely to be successful.

Further support to the importance of the coaching role, including discussion on correlating indicators, can be found in reference 3. Also, two recent articles [6, 7] support our findings. Seat performed a study of teams with and without coaches. In general, the article indicates that teams with coaches performed better than teams without coaches. Marin also found the most critical aspect of an optimal capstone experience to be an 'inspired (coach)'. Realizing the importance of the coaching role in capstone team/project success, our focus turned toward re-defining the coaching role.

### DEFINING A COACH'S ROLE

Our research shows that a successful coaching role encompasses three main responsibilities, as follows:

1. Mentor: providing support by showing the way. Being there, aware and helpful.
2. Mediator: a buffer between external reviewers and customers.
3. Manager (facilitator): guiding the team in both team processes and the design process.

The exact timing and degree to which a coach will perform these three main responsibilities of the coaching role will vary depending on the needs of the particular team. However, our research indicates that a coach will need to be able to consciously change and fill these different responsibilities at some point during the Capstone experience.

From these general responsibilities of the coaching role, we have established specific expectations and activities that a coach should fulfill to aid in the success of capstone teams.

It is important to note that it is not only *what* a coach does, but also *how* he or she does it that makes a successful team/project experience [7].

Because this coaching role is different than a traditional faculty role, training faculty to enable

Table 1. Capstone coaching role expectations and activities in team and design processes

<b>Team process: Helping your students become effective team members</b>	
<b>Learning</b>	
<i>General capstone expectations</i>	<i>Specific activities</i>
Support lecture and lab information	Positive verbal comments
Keep team on track for success	Watch for/encourage key indicators/activities
	Periodically evaluate/give feedback
<b>Apply learning to team experience</b>	
<i>General capstone expectations</i>	<i>Specific activities</i>
Specific team processes in place	Initial team process discussion
Specific team member roles	Reflection on team processes, as needed
Effective team member relationships	Establish team member roles, including team leader
Effective relationship with the liaison	Team opening social
Effective relationship with the team leader	Encourage open communication
	Initial team meeting with liaison
	Weekly contact with liaison
	Weekly meeting with team leader
<b>Design process: Helping your students become competent design engineers</b>	
<b>Learning</b>	
<i>General capstone expectations</i>	<i>Specific activities</i>
Support lecture and lab information	Positive verbal comments
Keep team on track for success	Watch for/encourage key indicators/activities
	Periodically evaluate/give feedback to each team member
<b>Applying to project</b>	
<i>General capstone expectations</i>	<i>Specific activities</i>
Appropriately scope project	Final scoping of project with liaison (prior to team input)
Common understanding of project	Additional scoping, if needed
Monitor project progress	Initial team project discussion ( <i>following</i> initial team process discussion)
	Attend weekly team meetings
	Give helpful suggestions/guidance
	Show how to do parts of design process
	Ensure weekly liaison contact
	Assist team in planning for and reflecting on reviews
	Assist team in self-assessments
	Review team deliverables
	Supervise team budget

them to be effective coaches is key to team learning and project success.

### INITIAL COACH TRAINING RESULTS

Various levels of coach training have been used in BYU's Capstone program since its inception. As the Capstone program has grown, there have been increasing needs for training. These needs were largely based on the use of more coaches from various backgrounds within the engineering college and business school. Beginning in fall of 1998, more emphasis in training was placed on the coaching role, with focus on the particular key indicators and activities as described above. Also added was support for coaches by way of periodic coach training seminars. These seminars provided various coaching tips and information, as well as an environment to discuss specific issues of concern.

Related to the formal training has been a program of observing team and coach interaction, with feedback to the coach. These observations have been directed in a collaborative effort with a faculty member in the Organizational Behavior area.

The results of this experimental change in focus and training for coaches have convinced us that this is a primary way to help assure successful outcomes for Capstone experiences. In terms of the training described above we have observed three important outcomes:

1. Providing support for coaches by way of training seminars is key in changing from a traditional faculty role to a coaching role.
2. Focusing on key indicators and activities gives coaches tangible tools to lead to a successful team/project experience.
3. Coaches desire and need feedback on their coaching performance *during* the experience in order to more effectively coach their team.

Through the studies we have also made additional consistent observations of coaching effectiveness and performance that are important to the ability to carry out the coaching role. These include:

- Coach background is key to their performance and training needs. There is a great need for coaches to have a feel for design and team processes and recognize the potential effectiveness of the use of these processes.
- Team make-up or composition can have a

significant effect on the team dynamics that a coach must learn to recognize and deal with.

- Selection and training of a student team leader by the coach is important.
- The coach must have a relationship with the project liaison that allows her to control scope, and manage the relationship of the sponsor and the team – especially early in the project.
- Personal and direct feedback to students individually from their coach is key to Capstone success. Faculty coaches are generally reluctant to give personal and direct feedback to students about their performance in a subjective setting such as design.

The above mentioned findings provide much of the foundation on which coach training is based. Through periodic coach training seminars, information and direction is given to help coaches perform more effectively.

## CONCLUSIONS

Our research has shown that in order for capstone students to have a successful (note our

definitions above) Capstone experience, faculty need to shift their role from the traditional lecturer or consultant to the role of a coach. There are specific indicators that coaches can use to monitor team/project progress and processes, and intervene in the team operation when appropriate.

We have also found that the role of a coach is key to team success. This role needs to be consciously changed during the progression of the project according to a particular team's needs. Properly focused coach training enhances faculty's ability to successfully coach design teams. Although training can be effective, the change required for some faculty can be difficult.

While we have done some general coach training in the past as noted above, we are now focusing on training that will help coaches use the key indicators. Results from our initial experience with this type of training indicates that such a direction is warranted. Our intention is to further develop coach training, as well as the increase the involvement of coaches in teaching the design process to the student team members. We believe this will increase the number of successful capstone team/project experiences.

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