AC 2010-817: DEVELOPMENT OF HIGH PERFORMANCE CAPSTONE PROJECT TEAMS AND THE SELECTION PROCESS

Stephen Laguette, University of California-Santa Barbara

Stephen Laguette received his BS, MS in Mechanical Engineering from UCLA. He is currently a Lecturer at the University of California, Santa Barbara in the Department of Mechanical Engineering and the Technology Management Program in the College of Engineering. His career has included executive R&D management positions with a number of medical device companies. He has been responsible for the creation of complex medical devices with over fifteen US patents issued in a variety of surgical fields including General Surgery, Plastic Surgery, Urology, Neurosurgery, ENT, Voice Restoration, and Ophthalmology. As the Director of Device Research for a major ophthalmic medical device company, he directed all research activities, the identification of new technologies, and the review of new business opportunities for the corporation. His responsibilities included transitioning projects into development and potential commercialization. He identified and successfully created research programs with leading academic institutions and formed strategic alliances with other high technology companies. In addition to his duties at UCSB, he remains active in the field of medical devices as a consultant for new ventures and investment firms.

Development of High Performance Capstone Project Teams and the Selection Process

Abstract

A successful Capstone Design program including companion design courses has been developed[1,2] that has become an integral and important component of the Mechanical Engineering curriculum. A variety of challenging projects are created each year to appeal to student academic and career interests. Students work in teams with the assistance of a faculty advisor to tackle a significant mechanical engineering design project. The formation of student teams can be a challenging and time consuming process that is critical to the success of the design project and the course experience. Attention has now been focused upon the formation of student teams and the selection process in the hopes of developing high performance student teams.

Successful student teams should include enthusiastic, motivated and engaged students as they must address the project over the academic year of the Fall, Winter and Spring quarters. The student team should also include satisfactory skills, technical or academic expertise required for each project. By including student preferences in the team formation process and careful assessment of student strengths and weaknesses, the development of a high performance Capstone project team may be more likely to occur.

This paper will address the experiences and the evolution of project team formation and the student selection process. It has now evolved to include an online process that allows the student to identify individual preferred project selections. The process also includes the ability to capture individual student academic and career interests as well as the expertise that may be offered towards the project and team.

Typical class size is between 75 and 110 senior ME students resulting in 15 to 22 projects and teams each year. The Capstone projects include Industry Partnered, Research Partnered, Student Competitions, and Independently created projects. The Capstone projects reflect the technical expertise of the department and faculty including solid mechanics, structures, materials, dynamics, systems and control, robotics, fluid mechanics, thermal sciences, computational science, and nanotechnology. Projects are created each year that vary in the type and the level of technical challenges to be addressed by the student teams.

This selection process has resulted in the elimination of dysfunctional teams in terms of performance and team dynamics, ensured a mix of skills and expertise, and has created a positive environment for high performance teams to flourish.

Introduction

A review of the published literature indicates that little attention has been given to the development of high performance Capstone Design student project teams. Attention in the

academic environment has been focused solely on team formation including random assignment, automating processes, algorithms, and methodologies[3,4,5,6,7]. These practices range from student self-selection to instructor assignment. The published literature provides little guidance in student team formation that could result in the creation of high performance teams.

The characteristics of "good' student teams and assessments have been presented[8,9]. However, these provide little guidance or assistance for others to follow.

A function-based approach has been introduced in terms of team member selection and qualitative assessment[10,11]. The authors conclude that their approach is robust in terms of promoting student motivation, enhancing student learning, and helping in retaining a higher level of knowledge in the students compared with traditional approaches. The authors indicate that a quantitative evaluation is currently being explored.

This paper will describe a student and team selection process that has been introduced in an attempt to develop high performance Capstone project teams.

High Performance Teams

Significant attention is given to building and leading high performance teams in the competitive business environment. In this environment, teams must work effectively across the organization to get tasks accomplished quickly and successfully to remain competitive. Many of the principles and qualities that have been described for project teams may be considered for student Capstone teams. This could result in improved team performance, project outcomes, and the student course experience.

A simple and effective description of a project team has been defined[12] and is applicable for the approach under consideration:

"A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable."

Using this definition, the driving factors for all project teams have also been described as follows[12,13]:

- All teams need a sense of purpose and a clear cut mission.
- All teams need the mission to be broken down into meaningful performance goals for each team member to pursue.
- All teams need to develop certain work approaches, procedures and processes to ensure that they accomplish a task efficiently and effectively.
- All teams have to support the common mission and take their individual responsibility seriously to do their part in accomplishing a task.
- All teams need a mix of skills, experience, and expertise, in order to meet the challenges of the team task.

To further differentiate the qualities of high performance team[12,13] as compared with average teams:

- A deeper sense of purpose
- Relatively more ambitious performance goals
- Better work approaches and outcomes
- Mutual accountability
- Complementary skills and expertise

Based upon these understandings, if the driving factors for all teams and the qualities of a high performance team are desirable for a student Capstone project team, randomly assigning students is clearly inappropriate and must be avoided. In addition, the probability of student self-selection providing complementary skills and experience is quite low without proper guidance and direction.

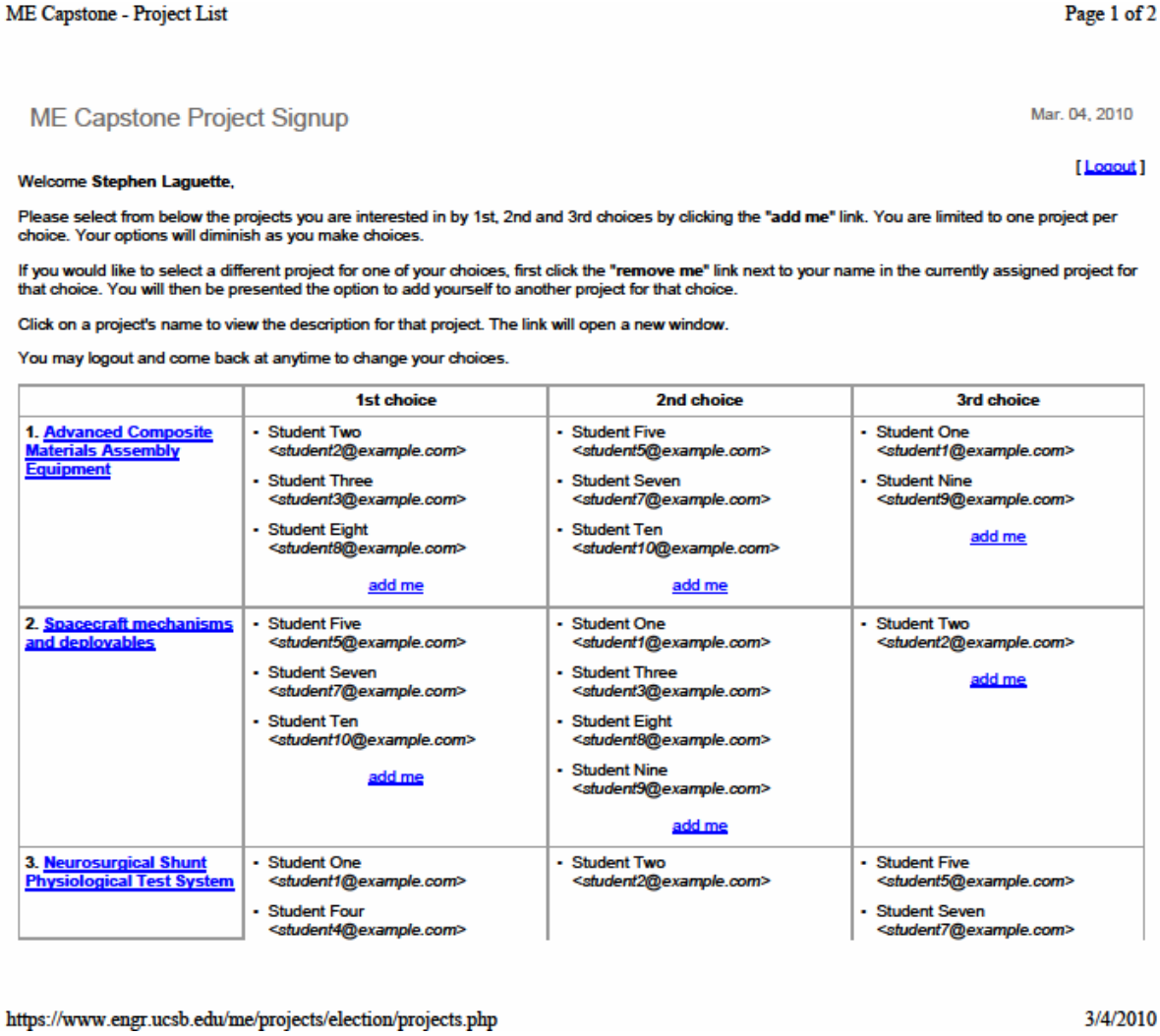
Successful student teams should first include enthusiastic, motivated and engaged students. The student team should also include complementary skills, technical or academic expertise required for each project. By including student preferences in the team formation process to better ensure engaged and motivated team members and careful assessment of student strengths and weaknesses, the development of a high performance Capstone project team is more likely to occur.

Student Project Selection

A set of design projects are created each year for student consideration. Projects are created each year that vary in the type and the level of technical challenges to be addressed by the student teams. These projects are intended to appeal to a variety of student career and academic interests.

A short description of each project is developed and provided to the students for consideration These projects and descriptions are posted on the course web site about three weeks before the start of school and the new academic year. Ideally the project description should provide some discussion of the expected technical challenges and desired project outcomes. Based upon the variety and types of projects that are created, these challenges range from very practical industry based projects, to more technically challenging research based projects, and various student competitions.

The incoming senior students are aware that the project list will be posted prior to start of school and are also alerted by email. The students may identify and select their top three preferences. An online process has been created and may be accessed from the course web site. This online process is limited to enrolled students and is password controlled. The selection table provides a link for each project name to the project description (Figure 1).



ME Capstone - Project List Page 1 of 2

ME Capstone Project Signup Mar. 04, 2010

[Logout]

Welcome **Stephen Laguette**,

Please select from below the projects you are interested in by 1st, 2nd and 3rd choices by clicking the **"add me"** link. You are limited to one project per choice. Your options will diminish as you make choices.

If you would like to select a different project for one of your choices, first click the **"remove me"** link next to your name in the currently assigned project for that choice. You will then be presented the option to add yourself to another project for that choice.

Click on a project's name to view the description for that project. The link will open a new window.

You may logout and come back at anytime to change your choices.

	1st choice	2nd choice	3rd choice
1. Advanced Composite Materials Assembly Equipment	• Student Two <student2@example.com> • Student Three <student3@example.com> • Student Eight <student8@example.com> add me	• Student Five <student5@example.com> • Student Seven <student7@example.com> • Student Ten <student10@example.com> add me	• Student One <student1@example.com> • Student Nine <student9@example.com> add me
2. Spacecraft mechanisms and deployables	• Student Five <student5@example.com> • Student Seven <student7@example.com> • Student Ten <student10@example.com> add me	• Student One <student1@example.com> • Student Three <student3@example.com> • Student Eight <student8@example.com> • Student Nine <student9@example.com> add me	• Student Two <student2@example.com> add me
3. Neurosurgical Shunt Physiological Test System	• Student One <student1@example.com> • Student Four <student4@example.com>	• Student Two <student2@example.com>	• Student Five <student5@example.com> • Student Seven <student7@example.com>

https://www.engr.ucsb.edu/me/projects/election/projects.php 3/4/2010

Figure 1. Project Selection Table

At the start of the school year and at the first class meeting, a Projects Kick-Off meeting is conducted. Each project is introduced by the sponsor and a brief description of the project is presented. Because of time constraints, not much project detail is provided. Interested students are introduced to the sponsor and contact information is provided for further more detailed meetings or discussions. These meetings and discussions are conducted during the first week of school.

Prior to the start of school and during the first week of school, when a student logs onto the course web site and the Projects Selection table, any previous student projects selections are also visible. This enables each student to identify the more popular projects and the other students interested in each project. The students are cautioned that each project is limited to five senior students. If they only select the more popular projects with significant student interest, the likelihood of obtaining one of their top three choices is poor. The students may revise their selections an unlimited number of times until the end of the first week of school. No preference is given in the final team selection process regarding any timing in the student selection. The selection table is closed to student access after the first week of school and the final team selection process is begun.

In addition to providing their top three project preferences, each student is required to provide a Self Assessment form. Each student is requested to provide information regarding their perceived individual skills or strengths that will be provided for the project team and for which they will be accountable. Each student is also requested to provide any comments or concerns regarding their projects selection. It is intended that the student provide their rationale or the basis of their interest in their selections. It is desired that this simple form provide information regarding student skills, expertise, and individual interests.

It should be noted that personal skills such as leadership, working styles, etc are not included in the Self Assessment form. In the context of the course, the team leader role has been defined as administrative only with no additional responsibilities.

Lastly, the students may also propose their own project team based upon the online student selections. The online process allows visibility for all interested students. A Projects Forum chat room is provided for student use on the course web site and is password controlled for access. This allows interested students to communicate with each other and propose their own teams.

The students are not guaranteed to be placed onto a team within their top three preferences.

Team Selection

The final team selection process is completed during the second week of school. The students have been required to provide their top three project preferences or selections and a self assessment form for accountability. Interested students have also proposed their own teams for consideration. In addition to the provided student information, a review of academic records is conducted to better ensure that student expertise matches the expected technical challenges for their project selections.

The students are advised at the start of the course that to excel, they must excel as a team. Individual performance alone will not be satisfactory. Due to the complexities of the projects and the complexities of the course deliverables, only high performing functional teams will excel. Average teams in terms of performance will reflect average grades. Dysfunctional teams will be problematic and will encounter difficulties in meeting the course deliverables and project deliverables.

The student teams are responsible for completing their engineering efforts each quarter and ultimately completing their project. These engineering efforts are generally characterized for the students as Prototyping, Testing, Modeling and Analysis for the purposes of the academic course experience.

The focus for final team selection is a proper mix of student skills, experience, and expertise, in order to meet the expected challenges of the engineering efforts. The team members should have identified a preference for the expected project challenges, possess the necessary skills, and have been made accountable for their roles and responsibilities in terms of Prototyping, Testing, Modeling, and Analysis.

Prior to the development of the online process, team selection efforts have included student self-selection and instructor assignment. Over the past few years, the process has gradually incorporated the use of a Self Assessment form, a Project Selection form, and an instructor review of academic records. These prior efforts have resulted in some problematic teams and have included:

- A team with no fabrication experience and no desire to actually build their project
- Some teams that have lacked the proper level of technical expertise
- Some teams that were a group of friends or roommates with poor motivation and work processes

Results

The 2009/2010 academic year is the first year that has incorporated a mandatory online project selection process, use of self assessment, required team skills for engineering efforts and review of academic records for final team selections.

This year's class is a total of 73 students. There were originally 24 projects presented to the students for consideration. Due to lack of student interest that was visible during the online process, 8 projects were eliminated from consideration prior to the start of school. The student teams are limited to a maximum of 5 senior students per team. A total of 15 project teams were created. These projects range from Industry-partnered including spacecraft deployment hinge mechanisms and surgical instruments, to Research-partnered including test capsules for extreme environmental conditions, and student competitions such as a vehicle challenge.

Of the 73 students, 49 (67%) were placed on their first selection, 10 (14%) on their second selection and 12 (16%) on their third selection. Only two students (3%) were placed on a project that they had not selected. Of these students, one student only provided two selections. The other student had selected three of the more popular projects and could not be placed onto one of these selections.

The students were also allowed to propose their own teams with the understanding that the team should have a complementary mix of skills, experience, and expertise to meet the anticipated

challenges presented by the selected projects. A team submittal needed to have a minimum of three members with the understanding that additional members would then be added.

There were 9 project teams submitted for consideration. There were 3 teams submitted with 5 team members that went forward as a complete team. There were 4 teams that were submitted with less than 5 team members that went forward with an additional assigned member. There were 2 team submittals that were rejected in terms of going forward due to concerns with complementary skills and expertise. These team submittals resulted in 7 (47%) of the 15 total project teams. The student efforts in developing and submitting their own project teams appeared to reflect a proper consideration of a mix of skills, experience, and expertise.

There were 8 (53%) project teams created based solely upon individual student preferences, the online project selections, self assessments, and a review of academic records.

The entire process of review and team determinations was completed during the second week of the quarter. It is estimated that this process required about 20 hours of instructor time. Time is needed to review all forms, ensure a proper mix of skills and expertise, and academic reviews once the teams are somewhat defined.

Teams are encouraged to meet during the third week of school to begin the forming process of team development. Some movement or re-assignment of students to other teams is possible with the review and approval of the instructor and all concerned. There were no student requests for re-assignment. All teams were finalized after the third week.

In addition to Self Assessment forms, a Team Survey was administered at the end of the Fall and Winter quarters for each student to assess their team dynamics and performance. Team self satisfaction appears to be very good for all teams based upon the survey. There does not appear to be any significant team conflicts or dysfunctional teams. All teams are performing well and project efforts for all teams appear to be very good overall. All teams have indicated that they are operating efficiently, enjoy working together, and that there is a positive atmosphere on the team.

A Design Review is conducted for all projects and teams as part of the course requirements for the Winter quarter. Design Reviews are attended by three independent faculty members not involved in the team selection process. These faculty provide a scoring for all reviews in terms of the quality of the Design Review, team dynamics, project activities, and the quality of designs. Additionally these faculty were asked to identify perceived high performance teams with a simple Team Assessment scoring rubric. The reviewers were unanimous in their selection of four teams. There were another two teams that were selected by single reviewers. For the purposes of this paper, only the four teams with unanimous selection have been identified as the high performance teams.

All four identified high performance teams were originally formed through the student team submittal process. Two of these teams were submitted with five students and no students were added to the team. One team was submitted with four students and one student was added. One team was submitted with three students and two students were added to the team.

It should also be noted that the lowest scoring team in terms of Design Review performance and Team Assessment in terms of faculty review was a team formed through the student team submittal process. Team performance is satisfactory and team dynamics are very good. There is no team dysfunction. The team also includes some of our better students academically. Course performance, although satisfactory, has been less than expected from this team.

A more detailed review of the student Team Surveys indicates no statistical differences among all teams in terms of overall satisfaction. All teams indicate general satisfaction with most scoring 4 to 5 of 5 and no scores lower than 3 of 5 by any student.

Conclusions

An online process of student project selections has been developed that is coupled with self-assessment forms and proposed team submittals. This process has yielded 97% overall success rate in meeting at least one of three preferences and a 67% success rate in meeting the student's first preference. Approximately 50% of the teams going forward were proposed by the students with some assigned team members. Approximately 50% of the teams were created by the course instructor with assignment based upon the complete process.

No students requested reassignment and no student were reassigned at team formation. The process has resulted in overall satisfaction in terms of team performance and team dynamics by all teams and all students as captured through student Self Assessments and Team Surveys.

The process has resulted in overall good performance for all teams in terms of the course deliverables and project deliverables as captured through independent faculty assessment of student team Design Reviews and Team Assessment. The process has resulted in the absence of dysfunctional teams and has ensured a satisfactory mix of skills and expertise for all teams.

The process has resulted in four high performance teams. All four teams were formed through the student team submittal process. None of the identified high performance teams were formed by the instructor. However, students were added to two of the teams. These results indicate that the student team submittal option should be maintained in the process. However, student team submittal in the selection process does not guarantee success.

An attempt has been made to create students teams that should be more engaged and motivated based upon student project preferences. Additional efforts have been incorporated to ensure a proper mix of skills and expertise with mutual accountability among the student team members. Team self satisfaction appears to be very good and team performance appears to be very good overall. The overall student satisfaction, the absence of significant team conflicts and the elimination of dysfunctional teams may also be important observations.

Future Efforts

It appears that allowing the students to propose and submit their team for consideration is successful in generating high performance teams. This will be continued in the selection process. Team Assessments and Team Surveys will also be conducted after project completion at the completion of the Spring Quarter. These results may be available for presentation at the ASEE conference in June.

High performance project teams require a deeper sense of purpose, relatively more ambitious performance goals, better work approaches and outcomes, with mutual accountability. The student team selection process is the first step in this process. Current efforts include the use of templates for project plans and design requirements for all Capstone teams as well as technical support from the faculty and staff engineers. It is anticipated that improvements in these areas will also be required.

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