

# Assessing and Improving a Senior Design Project Course for Undergraduates in Mechanical Engineering Based on New ABET Guidelines

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## Abstract

The Senior Design Project Course in Mechanical Engineering at the University of Wisconsin-Platteville offers a format of instruction and student participation that is centered around industry sponsored projects. The course is designed to serve as a transition from education to the practice of engineering to the graduating engineering student. The course is designed at the same time to meet the educational objectives consistent with the new ABET guidelines which offer flexibility of setting, assessing, and improving the goals of the course in particular and the curriculum at large. This paper addresses the developments in format, content, instruction, and student participation and their relation to the assessment plans, evaluation, and improvements in the Senior Design Project course. Design Process, Time Management, and Engineering Ethics are discussed as examples of the variety of topics covered in the course. Samples of assessment plans, evaluation, and subsequent improvements are also discussed.

## Introduction

The Senior Design Project course in Mechanical Engineering (ME 4930) at the University of Wisconsin - Platteville offers a format of instruction and student participation that is centered around industry sponsored projects. This capstone design course is offered each fall and spring with an average enrollment per semester of about thirty-five students. Project sponsors' funding is encouraged but is not mandatory. Students work on projects typically in groups of four or five. The course is designed to serve as a transition from education to the practice of engineering to the graduating engineering student. The course is designed at the same time to meet the educational objectives consistent with the new ABET guidelines which offer flexibility of setting, assessing, and improving the goals of the course in particular and the curriculum at large.

## Course of Study

As is often the case in most courses, the course of study for the Senior Design Project course is handed out to the students at the first meeting of the class. The typical course of study is a detailed document of about ten pages that addresses the course objectives, content, format of instruction and student participation, tasks and documentation required of the students, and method of evaluation. Particular aspects somewhat unique to the course addressed in particular include references to the subjective nature of the course that has to be evaluated objectively, design team formation

procedure, project assignment procedure, project initiation, guidelines and schedule of weekly progress reports, interim and final reports and presentations.

### Acquiring Industry Projects

As industry projects in the Senior Design Project course form the cornerstone of the design experience for the students, particular attention needs to be paid in acquiring the projects. Projects from various industries need to be sought thoughtfully weeks before the beginning of classes each semester. Several considerations go into this process. Meaningful and realistic projects have to be sought. Other considerations include student enrollment in the course that dictates the number of projects that will be undertaken in any particular semester, consideration to previous projects that may have to be continued, industry-university relations, nature of projects so as to cover the broad interests of mechanical engineering students, resources, and time. Typically, a forty to fifty percent oversubscription of projects is sought to ensure that all student design teams have a choice of projects that they are interested to take on. As a result, any particular project assignment from their choices that the professor decides is meaningful to them. The type and size of industries that have provided projects have been broad over the years.

A copy of all the projects procured under these considerations are made and kept ready to be given to each student team to consider. Typical information contained in the project description include correspondence letters, half to a full page of project background, statements of the problem and constraints, figures, and tables. This project description package is usually shared with student design teams at the first class meeting.

### Formation of Student Teams and Bidding on Projects

On the first day of class, after a self-introduction and overview of the course of study, the professor asks each student to introduce himself or herself, and importantly, asks each of them to briefly explain their subject interests and work experience. This helps every student to evaluate and seek compatible students as part of his or her design team. The students are then asked to form design teams (typically four or five per team). Once the teams are formed, each team is given a copy of the projects' description package. Each of the numbered projects is addressed briefly by the instructor. A bidding form is then handed out to each team. The bidding form asks each team to

- \* go over each project proposal carefully and in a brisk manner for suitability - in doing so, to address individual interests and capabilities, project objectives, team interests and capabilities, and the match between the project objectives and team objectives vis-a-vis each project.
- \* rate each project as a team - the rating may be based on a method chosen by the team or on a suitable combination of individual ratings.
- \* enter the highest rated top three or four projects into the table given in the bidding form along with weights of priority. The weights must add up to 100 but can add up to that in any combination including equal weights.

After the bidding forms are completed and returned, the students are asked to provide individual schedules (to facilitate planning of upcoming project initiation field trips) to the professor. The students are then told that project assignments to teams will be made at the next (second) class

meeting and that they must be prepared to travel once or twice in the immediate short term to the project sponsor - up to a whole day of travel or even more is involved in some cases. It is obvious that there is more than normal activity prior to and during the first few weeks of the class.

## Project Assignments

Projects assignments to the design teams are made by the professor before announcing the assignments at the second class meeting. This important task of project assignments to the teams is based on the priorities provided by the design teams, conflicts / compatibility of the choices amongst the teams, and other factors alluded to earlier in the section on acquisition of projects. Good planning greatly facilitates the completion of this important and difficult task. The sponsors are contacted and informed of the possibility of their project being taken up. Tentative project initiation field trip schedules are also finalized during this discussion with the sponsors. Once the project assignments and project initiation field trip schedules are decided, a handout that includes the tentative title of the assigned project, the names of team members, the names and addresses of sponsor contacts, details of the project initiation field trip to the sponsor's location, and a checklist of things to prepare so as to effectively partake in discussions with the sponsor. The checklist includes preparing a list of project related questions and communication protocol queries.

## Project Initiation Field Trips

The project initiation field trips to the sponsor's locations are typically undertaken during the first few weeks of classes. The field trips are undertaken this early so as to get the projects started in right earnest thereby giving the maximum possible time for the design teams to work on their projects. The project initiation field trips are often an exciting experience both to the students and the professor. The students begin to focus on their project from almost the very beginning. The student teams obtain answers to the checklist of questions, take photographs / video of specific aspects of the system they are dealing with, and begin to get a much better understanding of the problem. The field trip helps the professor to understand more about the particular project the student team is undertaking, gain a wider knowledge of industrial practice that can be shared with students in classes, keep up with technological developments and enhance university-industry relations.

## Progression of the Projects

Unlike a regular lecture class, the intensity and nature of work undertaken vary from one team to another and from one week to another week due to several factors - very much akin to real life engineering situations. It is important though for the professor to oversee all these developments in a manner that promotes self initiated and driven activities by students as individuals and teams and yet be guided in the right direction where needed by the professor. Certain feedback mechanisms facilitate this process. One of these is the preparation of a document called the Scope of Project Agreement. The students go through iterations of draft preparation of this document, first as individuals and eventually as a team before all involved parties including the team, professor, and sponsors agree and sign on to the final version of the Scope of Project Agreement document. The preparation of the Scope of Project Agreement helps the students to experience some aspects of the

real world engineering such as the scope of the project itself, responsibilities, time, resources, other constraints, and project management. Students often appreciate the scope and importance of the Scope of Project Agreement much more toward the end of their project - one proof of it lies in the fact that they read the Agreement more closely as they approach the final stages of their project !

The Scope of Project Agreement also serves as an inlet to further understanding of the issues of each project over the next few weeks and months of the project. Students manage the projects as individuals and teams, and the professor in turn manages all these overall. Student teams meet with the professor at approximately weekly intervals. Before the meetings, they submit weekly progress reports that help the professor to be more effective during the meetings. Weekly progress reports and meetings are a feedback mechanism for the professor to evaluate the progress of various projects. The student design teams meet amongst themselves at about the same frequency. Each team's Gantt chart provides the reference schedule and activities to be accomplished each week. Students are asked to take on individual responsibility for different activities of the Gantt chart and are also asked to take on project manager roles at different times. By doing so, the productivity of the team is improved and at the same time, individual responsibility and management skills are enhanced. Design teams are also required to produce an interim report / presentation, and a final report / presentation. The final presentation at the end of the semester is given to an audience comprising of faculty, fellow students, and industry project sponsors. The interim and final reports/presentations are of course important feedback sources for evaluating how well the students accomplished the project tasks.

Although the design project forms the central part of the course, the project experience by itself will be incomplete and perhaps even incorrect without learning and implementing related subjects. Examples of related subjects include design process, project management, social and ethical issues. Lectures, discussions and student participation on such subjects are needed. The past experiences of doing so and the new ABET guidelines have been instrumental in making significant improvements in this aspect of the Senior Project Course. For example, part of Section I.C.3.d.(3)(c) of the 2000-2001 Criteria for Accrediting Engineering Programs<sup>1</sup> states : "The engineering design component of a curriculum must include most of the following features: development of student creativity, use of open-ended problems, development and use of modern design theory and methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, production processes, concurrent engineering design, and detailed system descriptions. Further, it is essential to include a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impact." This section alone points to several important subjects to be addressed as part of the design experience. It is important to ensure that the Senior Project course addresses any of these subjects that have not been dealt with at all or only minimally before. It is also important in the course to review subjects that have been dealt with before in a manner that brings a certain degree of finality and connectivity. Of course, as part of curriculum development, many of these subjects need to be addressed more thoroughly in other courses on an on-going basis. Some of the subjects that are addressed in the Senior Design course within the context outlined above are presented here. One is the design process. It is important for the graduating engineer to "make it a habit" to use an engineering design process and suitable design methods at various stages of the process in dealing with the projects.

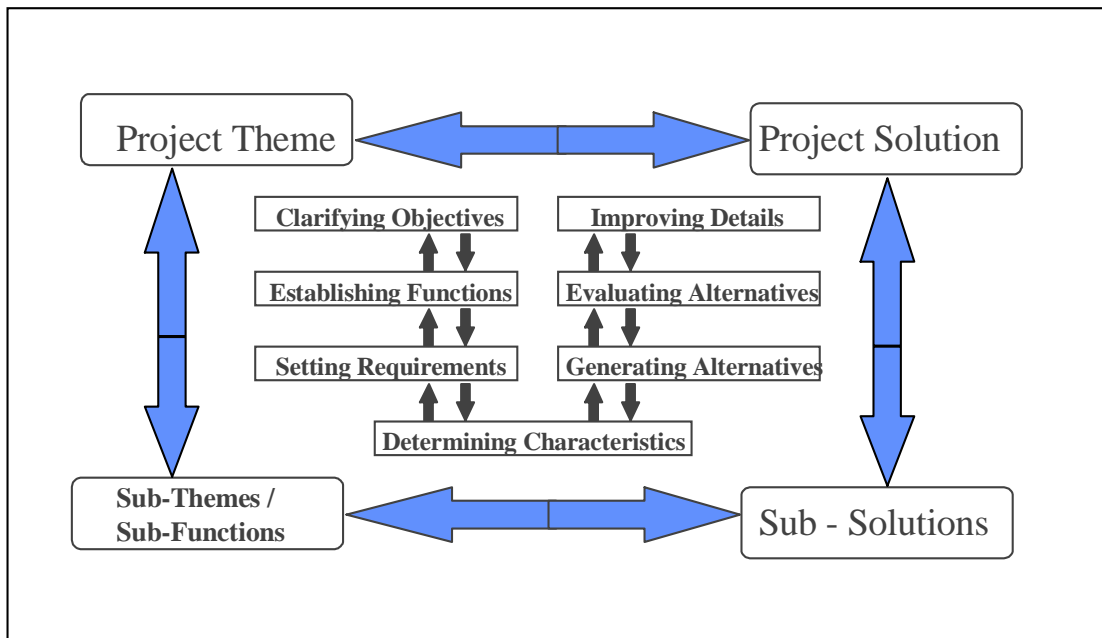


Fig. 1

To accomplish this objective, a design process that is neither too broad nor too narrow along with design methods for each stage of the process needs to be presented so that it is most informative and even directly helpful to most teams. The Symmetrical Problem Solution model<sup>2</sup> shown in Fig. 1 is one such design process that fits this objective and is presented to the students as a summary review of the design process. Design methods reviewed or introduced in conjunction with the various stages of such a design process include brainstorming, objectives tree, function analysis flowchart, performance specifications, alternative solutions, morphological chart, weighted objectives table or decision matrix, and value engineering. Top-down and bottom-up approaches to design are encouraged for consideration. Other subjects addressed in the course include project management strategies<sup>3</sup>, engineering ethics<sup>4</sup> including case studies<sup>5</sup> and student's decisions on such case studies, and time management. Continuous improvement of the multi-faceted Senior Design course is being made using assessment plans and feedback that have become more formal and objective due to the new ABET guidelines. For example, each semester, a course assessment survey of course goals and how well they have been met is given to the students. The surveys are evaluated and improvements are made.

## Conclusions

The objectives of the Senior Design course based on the goals and mission of our program, department, college, and university and made feasible by new ABET guidelines, assessment and improvement plans provide a sound design experience to the Mechanical Engineering students at

UW-Platteville. This paper has presented the objectives of the Senior Design Project course as well as the strategy and format that has been adopted in the course to achieve the objectives consistent with the new ABET guidelines. The new ABET guidelines have been very helpful to continuously improve the course in a more formal and objective manner.

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