Teaching Credit for Supervising Capstone Design Projects

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The Mechanical and Mechatronic Engineering programs at California State University Chico conclude with a common two-semester course sequence in capstone design. Projects are generally sponsored by industrial partners and all work is accomplished in teams. The first semester focuses on design while the second is dedicated to building and testing a working prototype. All project teams are assigned a faculty advisor for the duration of the year-long design project.

Prior to the 2008/2009 academic year, senior exit surveys, along with substantial anecdotal evidence, repeatedly identified advisement of capstone design projects as a problem area in the curriculum. During that time, faculty advising of capstone design projects was unstructured and inconsistent. While some advisors took a very active role, others presumed their only responsibility was to assist with technical aspects on an as-needed basis. The underlying problem was that no formal guidelines existed; advisors were appointed to supervise projects and proceeded in whatever fashion they felt was most appropriate.

A year-long effort was undertaken to improve supervision of capstone design projects. Results of the work included clear definition of the faculty advisor's role, consistent advising across groups, and a collection of best practices. An additional, unintended benefit resulting from the work was a formula for computing workload credit for faculty supervision of capstone design projects.

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Overview of Capstone Design

As with many engineering programs, the mechanical and mechatronic engineering curricula at California State University Chico utilize a two-semester capstone course in senior design project. The intent is for students to utilize competencies developed in the first three years of the curriculum in the solution of a real-world design problem. The first semester is predominantly spent in design activities, while the second encompasses prototype building and testing. Projects are primarily sponsored by local industry, which is a recent focus of the program. This new approach of generating projects through industrial partnerships is consistent with many capstone engineering courses nationwide[1].

During the first semester, weekly lectures are given that cover many aspects of the design process. Selected topics include customer requirements and specifications, conceptual design, decision making, project management, cost estimating, budgets, simulation, documentation, and formal reports. Each project group is required to give three oral presentations during the semester. The presentation topics are project proposal, midterm review, and final design. The semester concludes with submission of a comprehensive design report.

The spring semester includes less time in the classroom and more time spent building and testing the designs. Students are required to develop a comprehensive test plan to prove the specifications developed in the fall semester. They then fabricate and test the design, and in most cases, proceed directly to redesign activities. The semester concludes with a final oral presentation, a poster and display of the prototype, and submission of a comprehensive written report.

The design projects are accomplished by student groups[2], as the ability to work in groups is one of the measured outcomes of the course. Groups typically number four to five, but may vary based on the complexity of the assigned project. Groups may be made up entirely of mechanical engineering majors, or may also include mechatronic engineering majors depending on the technical aspects of the project. Regardless, each group is assigned a single faculty advisor for the duration of the project, considered by many to be a critical element[3] of the student's design experience.

Past Issues

Prior to the 2008/2009 academic year, faculty mentorship of capstone design projects was generally unstructured and inconsistent. Many advisors took the approach that they were only there to assist the students on an as-needed basis. A common attitude conveyed to the students was "come by if you need anything." Assistance was generally restricted to technical aspects of the project within the expertise areas of the individual faculty members. Other advisors did take a more active role in the projects, with regularly scheduled meetings, required progress reports, and other supervisory activities, but this would be considered the exception rather than the norm.

A major problem was that no formal instructions were ever given to faculty advisors; they were just appointed to supervise projects and proceeded in whatever fashion they felt was most appropriate. Another significant issue was that no workload credit was given for advising projects; they were simply divided up among the faculty and were an expected part of everyone's job.

As a part of standard assessment activities, the department administers exit surveys to all graduating seniors. For many years, these surveys, along with substantial anecdotal evidence, have repeatedly identified advisement of senior projects as a problem area in the curriculum. Numerous issues have been identified, illustrating that current advisement practices were at best uneven, and at worse severely lacking.

Fixing the Problem

In order to address this clear deficiency in the program, the department faculty began what turned out to be a year-long process of defining the role of the faculty advisor in the capstone design course. Goals of the effort included a clearer understanding of the advisor's role by students (as well as faculty), more consistent advising across groups, and a better overall design experience for the students. Many issues were discussed during the process, with eventual resolution to everyone's agreement. Primary issues that surfaced during the discussions were:

- Frequency of meetings with student groups
- Content of group meetings
- Project management role
- Overall responsibility for project success
- Grading responsibilities
- Review and input of student's design logbooks
- Approval of milestones
- Attendance at presentations and other events

The primary expected outcome of the discussions was a clear definition of the role of the faculty advisor[4] which led to consistent advising across groups. Additional outcomes included identification of best practices for advising capstone projects[5] and establishing a formula for workload credit for advising capstone design projects.

Workload Calculations

CSU Chico is primarily an undergraduate teaching institution and has, by comparison, higher teaching loads that many institutions. Faculty workload is governed by the university's Faculty Personnel Policies & Procedures[6] (FPPP) manual. Full time tenured and tenure- track faculty are expected to teach an average of twelve weighted teaching units (WTU) per semester. WTU calculations vary based on the type of course being taught. In the engineering curriculum, the common designations are Lecture, Activity, and Laboratory. The associated WTU values for these types of instruction are summarized in Table 1:

Table 1 – Teaching Credit for Course Elements

Category	Hours / Unit	WTU / Unit
Lecture	1	1
Activity	2	1.3
Laboratory	3	2

Many engineering courses, such as Dynamics, are taught in a traditional lecture-only format. A typical class section meets for an hour (actually 50 minutes) three times per week. At a one-to-one ratio, the faculty member has three contact hours and earns 3.0 WTU. The student earns three credit hours.

Other engineering courses, such as Statics, are taught with a combination of lecture and activity. The entire class attends two one-hour lectures each week. The class is then divided into smaller groups that attend a two-hour activity each week, allowing for supervised, in-class assignments and individual help from the instructor in a small-class environment. As an example, a Statics section that contains sixty students might be divided into three activities of twenty students each. The instructor has eight contact hours (two one-hour lectures and three two-hour activities), and earns 1.0 WTU for each lecture and 1.3 WTU for each activity. This totals 5.9 WTU for the instructor while the student still earns three credit hours.

Many engineering courses have traditional laboratory elements that typically last three hours. Each laboratory section provides 2.0 WTU for the instructor while the students earn 1 credit hour. As an example, a course in Materials that contains sixty students would have a common one-hour lecture three days per week plus three three-hour laboratory sections of twenty students each. The instructor has twelve contact hours and earns 9.0 WTU while the student earns four credit hours.

Due to the various configurations of courses with lectures, activities, and labs, most tenured and tenure-track professors in the department teach either two to three courses per semester. Prior to this work, supervision of capstone design projects was not considered in the calculation of teaching load; they were simply added on top, and done "out of hide."

Equating Project Supervision to Workload

Once the role of the advisor was clearly defined, faculty went through all of the tasks and expectations to estimate the amount of time spent supervising a typical capstone design project. Specific details have already been disseminated[4], but a summary of expected advisor activities is provided here:

- Weekly group meetings
- Communications with project sponsor
- Approval of course milestones
- Review and pre-approval of all presentations
- Attendance at all presentations
- Grade input for all presentations
- Review of draft design report
- Grading of final design report from another group
- Evaluating each group member for contribution
- Evaluating each group member for teamwork
- Assisting with technical aspects of the design
- Reviewing calculations, assumptions, methodology of design
- Review and approval of final Bill of Material
- Review of working drawings
- Pre-approval of all purchases in excess of $100

After thoughtful review and estimation of time commitments, it was agreed that supervision of a typical design project with a four-person team should equate to about 1.0 WTU per semester.

It turns out that the FPPP already includes a workload definition called Supervision that awards .25 WTU per student per semester. This provided a smooth means to award 1.0 WTU to a faculty advisor supervising a four-person group, and 1.2 WTU for a five-person group.

As a point of comparison with other institutions that may not use a similar algorithm for workload, supervising **one capstone design project equates to 1/3 of a traditional three-unit lecture course**. Comparisons may also be drawn from Table 2, which is based on the example classes described above and assumes four-person project teams.

Teaching the Actual Course

In addition to advising project teams, the course itself poses difficulties with work load computations, as it is like no other course in the curriculum. The course has two one-hour lectures per week in the first semester. This provides the course instructor only 2.0 WTU or only 1/6 of a full teaching load. The course drops to a single one-hour lecture per week in the second semester, providing 1.0 WTU or 1/12 of a load for the instructor.

Table 2 – Course Equivalencies

Class Format	Equivalent Number of Groups	Portion of Overall Load
Three Unit Lecture (e.g. Dynamics)	3	25%
Two Unit Lecture with three Activity Sections (e.g. Statics)	~6	~50%
Three Unit Lecture with three Laboratory Sections	9	75%

As many readers will attest, there is much more to teaching capstone design than simply delivering two one-hour lectures per week. Project recruitment can take anywhere from weeks to months with countless hours spent on the phone, writing emails, or traveling to potential sponsors' facilities. Assigning students to projects[2] is another time consuming activity that falls outside of normal teaching duties. And once student teams are formed, advisors assigned, and projects underway, it is inevitable that issues will arise requiring time and effort on the part of the course instructor. Examples include projects expanding in scope and scale, sponsors arbitrarily changing requirements, insufficient funding for fabrication and testing of prototypes, and the all too common issues of team dynamics that cannot be resolved by the faculty advisor.

These workload issues have been addressed here with two different approaches. The course instructor is awarded one additional WTU per semester for "course coordination," increasing the workload credit to 3.0 and 2.0 WTU for the first and second semesters respectively. Project recruitment, which often requires significant work over the otherwise unpaid summer, is rewarded through a summer stipend financed funded from the previous year's sponsor allocations.

Implementation

As a means of one final comparison, the combined student population in the mechanical and mechatronic engineering capstone design course has averaged about 70 students and 16 project teams the past few years. The total WTU of the instructor and the project advisors combined equates to about 20 WTU per semester to deliver the course, or about 1.67 full time faculty positions. This makes capstone design a very "expensive' course to deliver.

Awarding workload credit for project supervision, as compared to faculty performing the work "out of hide," increased the department teaching load by more than one full-time faculty position. Faculty were skeptical that the administration would approve the new workload model and its associated cost.

But fortunately, the current administration places a high value on capstone design and the many tangible benefits it provides. This institution places a high value on industrial partnerships and activities that benefit local employers. External funding of the students' design projects is another attractive element. Finally, the visibility attained through partnerships and the spring Design Expo is seen as a value to the college and the university as a whole.

Conclusion

In the time that the teaching credit model has been implemented, advisors have taken a much more active and consistent role in project supervision. This has led to increased student satisfaction, as evidenced by significant improvement in senior exit survey data. It has also led to increased project quality and increased sponsor satisfaction, as evidenced by increased participation and funding from external sponsors. The program's visibility on campus has increased, and the real-world aspect of the design projects has been of great benefit to the students.

References

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