Optimizing the Structure for a Multidisciplinary Senior Design Experience

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Abstract

Students in Mechanical Engineering and Electrical and Computer Engineering at Valparaiso University take a multidisciplinary capstone senior design course. After the first two years of the course's inception, it was revised in the summer of 2003 to incorporate suggestions of students and faculty in a continuous improvement effort. Changes to the course structure were instituted and course content materials were developed during the summer effort. The course now operates as several autonomous sections with a team approach that maintains a base level of consistency. Although only partially through the first year of the changes, initial feedback indicates that the changes have been well-received, more effectively delivering the design experience to the students, while more effectively utilizing faculty teaching load.

Introduction

The capstone senior design experience for Mechanical Engineering (ME) and Electrical and Computer Engineering (ECE) students at Valparaiso University has rapidly developed into a valuable learning experience. The course sequence covers two semesters, and provides a multidisciplinary experience to students in both the mechanical and electrical/computer disciplines. In the 2000-01 academic year, the senior design sequence was split out by department, but in the summer of 2001 the courses were merged by the ME and ECE departments[1].

The senior design curriculum development was motivated by a need to place additional emphasis on developing student skills in product design and effective teamwork. Curriculum development has focused here since the introduction of Engineering Criteria 2000 by the Accreditation Board for Engineering and Technology[2]. Additionally, multidisciplinary design and teamwork have been active areas in curriculum development at other universities[3-7].

For two years, 2001-02 and 2002-03, Senior Design remained in the same basic form. The course was headed by a lead professor from each department with support from approximately four faculty members from each department in technical advisory roles. The course was conducted in a large group setting with breakout sessions for the individual design teams. Each team had five to six students with an approximately equal balance between ME and ECE students. The first semester was devoted primarily to defining system requirements, researching related topics, and generating the electro-mechanical design. The second semester focused on production of the prototype and its subsequent testing. These first two years proved to be good in providing the ME and ECE students with a multidisciplinary capstone design experience, but there was definite room for improvement.

In the summer of 2003, the Dale Kempf Engineering Curriculum Development Grant provided the means to move this course sequence into the next phase. This grant, made possible by the generous donation of current Valparaiso University ECE professor, Dale Kempf, is awarded annually to revise existing or develop new courses within the College of Engineering. The content of the course was modified only slightly with the two semesters maintaining their basic focus. The course structure and administration changed significantly. Supporting course materials were developed and distributed to each faculty member prior to the course start, and Blackboard was used to communicate and to share documents electronically. Initial feedback from faculty, students, and administration show that these improvements have been well-received.

Assessing the Course

Although the senior design sequence was meeting the basic needs of the students, the course structure was cumbersome, and at times, confusing. Students were completing many assignments that were valuable, but often overlapped previous assignments. The course structure engaged approximately 10 faculty members each semester, and those faculty were not necessarily the same from the first semester to the second. The students were often caught in a circular trap, unsure whether to go to the lead faculty member in the course or the individual project advisor.

The College of Engineering was also charged with the challenge of reassessing its curriculum to ensure that teaching loads were appropriate and distributed as effectively as possible. The engagement of 10 faculty members each semester pointed to the need to reassess the structure of the course. The ambiguity of accountability for the students pointed to the need to reassess responsibilities.

As with every course in the college, the senior design course was evaluated by students at the end of each semester. The numerical scores, and especially the comments, from the evaluations were used to begin the framework for a course restructure. Additionally, a brainstorming session was held at the conclusion of the 2002-03 academic year, including eight of the faculty members involved in the course. The combination of this student and faculty feedback led to the Summer 2003 curriculum restructure efforts.

The projects themselves did not change with the restructure. Each project continues to hold significant electrical, computer, and mechanical components. Sample projects for the 2003-2004 academic years include:

- A 3-D scanner that uses a laser scan to generate a point cloud that represents a physical object that is translated into a virtual reality system.
- A fly zapper that uses machine vision to detect a black spot on a white field (a “fly on the wall”), then actuates servo motors to hit the spot with a pulse of a laser.
- A remotely controlled robot that competes in the AMD Jerry Sanders Creative Design Competition, held at the University of Illinois at Urbana-Champaign.
- A surgical knife, developed in conjunction with a local physician, to aid in reconstructive knee surgery.

As in the previous academic year, students are placed on project teams by the faculty advisors. Students have some input on which projects they prefer, and an effort is made to accommodate student wishes, while preserving balance on each team. Each project is carried

from concept to completion by team members, going through various stages from brainstorming all the way to a physical prototype that is tested, then presented in various capacities.

Course Improvements

Following the collection of student and faculty inputs, curriculum improvement efforts were focused on two main areas: (1) developing a new administrative course structure, and (2) developing a set of exemplary materials to be used by faculty involved in the course.

The restructuring of the course includes the following format:

- The new course consists of six pseudo-independent sections.
- Each section is managed by a single faculty member.
- Three ME faculty and three ECE faculty are responsible for the six sections.
- Each section consists of two multidisciplinary teams of 4-6 students.
- Each team consists of ME and ECE students.
- Each instructor has complete jurisdiction for his section.
- Each section has a technical advisor in the alternate discipline of the instructor (e.g., a section headed by an ME instructor has an ECE technical advisor).
- Group lectures are presented several times each semester to all six sections.
- Each faculty member delivers one or two lectures for the large group session, including topics such as sustainability, hazard analysis, project planning, testing and verification, engineering ethics, patents, entrepreneurship, and professional licensure.
- Weekly advisor meetings (WAMs) are held with all six faculty in attendance to address administrative and creative issues.

The exemplary materials developed as resources for each instructor include electronic copies of the following:

- Course syllabus, schedule, and grading format
- A handout detailing each assignment on the proposed schedule
- Example assignments, as appropriate
- Suggested grade sheets for each assignment
- An electronic template for the assignment as appropriate

At the same time that these course improvements were instituted, the university moved to Blackboard as the online tool for faculty to communicate and share electronic information with students. These exemplary course documents were posted in Blackboard by each advisor, allowing students to download explanations of assignments, recommended document formats, and example assignments.

In making each instructor responsible for an individual section of the course, each has the autonomy to make course changes, as desired. Documents such as the syllabus, assignment handouts, etc. are subject to change, as well. This flexibility is necessary to accommodate individual instructor preferences, as well as varying project needs. To further support the accountability of the new structure, all instructors are the same for the second half of the design sequence, thus correcting the problem of advisors that changed between semesters in some cases.

Course Evaluation and Initial Feedback

Results of the effectiveness of the changes are still very preliminary, but the initial indications are that the changes have been well-received by students, faculty, and administration. It is difficult to quantify a general atmosphere, but those faculty who were involved with the course during the 2002-03 academic year and Fall 2003 semester have noted a significant improvement in student enthusiasm. Student course evaluations for Fall 2002 to Fall 2003 improved from a numerical ranking of 3.79 to 4.28 on a 5-point scale—a 13% improvement. Most notably, student comments on those same two sets of evaluations moved from a general tone of harsh, critical, and angry to one of satisfied, constructive, and enthusiastic. Advisors have noted that project reports and overall quality are better than the corresponding time one year previous. Additionally, project teams have begun their construction phase earlier than their counterparts last year. Peripheral comments from outside faculty and college administration indicate that the improvements have been beneficial to the course sequence.

Conclusions

The course restructuring efforts have been implemented for the first half of the design sequence. The true test will come with the completion of the second half. The course structure for the second semester will follow that of the first. Improvements that have already been realized in the first half of the sequence include the following:

- Increased student involvement and satisfaction
- Reduced overall faculty workload
- Improved clarity in faculty responsibilities
- Increased team performance
- Improved performance on projects

The challenge facing the faculty will be to institutionalize all changes that have been made, while continuing to develop this course as a positive multidisciplinary design experience for the ME and ECE students at Valparaiso University.

References

1. Tougaw, D. and Will, J. "An Innovative Multidisciplinary Capstone Design Course Sequence," *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition*, June 2003.

2. Accreditation Board for Engineering and Technology, *Criteria for Accrediting Engineering Programs*, Baltimore, MD, 2002.

3. Olds, B. M., M. J. Pavelich, and F. R. Yearts, "Teaching the Design Process to Freshmen and Sophomores," *Engineering Education*, July/August 1990, pp. 554-559.

4. King, R. H., T. E. Parker, T. P. Grover, J. P. Goshink, and N. T. Middleton, "A Multidisciplinary Engineering Laboratory Course," *Journal of Engineering Education*, vol. 88, no. 3, 1999, pp. 311-317.

5. Miller, R. L., and B. M. Olds, "A Model Curriculum for a Capstone Course in Multidisciplinary Engineering Design," *Journal of Engineering Education*, vol. 83, no. 4, 1994, pp. 311- 316.

6. Phillips, J. R. and A. Bright, "The Harvey Mudd Engineering Clinic: Past, Present, and Future," *Journal of Engineering Education*, vol. 88, no. 2, 1999, pp 189-195.

7. Maskell, D. "Student-Based Assessment in a Multi-Disciplinary, Problem-Based Learning Environment," *Journal of Engineering Education*, vol. 88, no. 2, 1999, pp. 237-243.

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