A Combined Electrical and Mechanical Engineering Senior Design Laboratory

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Abstract

This paper describes a multidisciplinary capstone design laboratory course offered in the Electrical and Mechanical Engineering Departments at Texas Tech University. The course uses projects from industry, research efforts and other faculty initiatives.

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Introduction

In the fall semester of 1994 the Electrical and Mechanical Engineering Departments at Texas Tech University began a multidisciplinary senior design project laboratory program. Two courses were established by integrating the Electrical Engineering Department's Senior Project Laboratory courses (two 3-semester credit hour courses) with the Mechanical Engineering Department's Design I and II capstone design courses (two 3-semester credit hour courses). The Electrical Engineering Department has a long history of project laboratories.[1-5] The Mechanical Engineering Department has been involved in alternative fueled vehicles for a number of years. Both departments had worked together on a number of special projects and felt the need, as have many others[6-11], for an increased interdisciplinary program for engineering students. The goals of these new courses were:

- to have the students develop an understanding of engineering design projects from recognition of a need and definition of design objectives through completion of the project
- to foster student creativity
- to broaden the students concept of engineering problems to include other engineering disciplines and other nonengineering factors that have an impact on the final problem solution
- to provide a unique educational experience for students on project teams
- to enhance the students communication skills

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Lectures

This multidisciplinary course includes both electrical and mechanical engineering students. The entire class meets for lectures for one hour each week. The lectures are presented by faculty from the Electrical and Mechanical Engineering Departments or industrial representatives selected by the faculty team. The material covered during lectures is taken from the textbook, *The Engineering Design Process*, by Ertas and Jones and other appropriate references.

The lecture material supports and augments project activities. Grades on the lecture portion of this course are based on class attendance, class participation, problems related to the material presented or periodic quizzes.

Projects

Projects may be either one or two semesters in length. Students assigned to projects of one semester length during the fall semester must select another project for the spring semester. Specific project deliverables are determined by the student project group in conjunction with the responsible faculty advisor, the course instructors and the laboratory director's staff.

A menu of projects available for the semester is presented and described at the first class meeting. Students prioritized the projects in which they are interested and submit this list to the course instructors within two days. Project assignments are made and posted in the EE and ME Departments the day after the list are submitted. Student project groups meet with their faculty advisors (and other appropriate personnel) immediately thereafter. Project planning, schedules and deliverables are discussed at these meetings.

Reporting

For all projects each student gives periodic oral progress reports. The class is divided into smaller sections for a three-hour weekly meeting for the reports. These oral reports are presented by the project group or team with each student reporting on the portion of the project for which they are responsible. This is one of the primary ways in which each student's effort on the project is evaluated. These presentations are made in separate, smaller groups. Oral progress reports must include:

- status of each individual member's weekly deliverables,
- technical details on the project (diagrams, flow charts, schematics, design decisions, parts selection, etc.),
- accomplishments during the week,
- updated project schedule with changes indicated,
- deliverables and effort scheduled for the upcoming week,
- identification of problems,
- updated budget with changes indicated,
- indication that the project advisor has approved the progress report.

The first scheduled progress report is an oral presentation on the project group's proposal.

This oral presentation must be well organized and include visual aids. Each member of the project team is required to speak during all oral presentations. These presentations must be organized so that each student has approximately the same amount of presentation time. The presentations must contain enough technical information for students and instructors to fully understand the direction of the project. After the presentation, the instructors and students from other groups ask questions related to the project. All team members are equally responsible for answering questions following the presentation. Each student has approximately 5 minutes to present his/her portion of the project.

After about 5 weeks (1/3 of the semester), design reviews with individual project groups are held in lieu of oral progress reports. These design reviews consist of an in-depth oral presentation on the design by the project group with interactive critique from course instructors, faculty advisors and other invited guests. Individual students have 15 minutes to present their part of the overall project design. For the design review students must be prepared to defend their design concept and approach. Oral progress reporting will resume after all project groups have completed their design review.

A written progress report is also submitted weekly by each student identifying their progress for the past week as well as problems encountered, and outlining plans for the upcoming week. Although individual students prepare these progress reports they are submitted as a project group report with the individual reports stapled together. These written progress reports are due each week at the beginning of Oral Presentation time. Student groups are required to meet with their project advisor to discuss these weekly progress reports and the advisor signs the report indicating that the group has briefed him/her.

Each team member keeps a project notebook. This notebook is turned in at the completion of the project. The notebook should be a loose-leaf, three-ring binder type. All project related work should be kept in this notebook. This notebook is used as a partial measure of the work accomplished on the project by the team member.

Written proposals are prepared for all projects and oral presentations are made describing the proposed approach, budget requirements and schedule for completing the work. These written proposals are graded, handed back for corrections, and resubmitted. Project final oral presentations are made and written reports submitted at the end of the semester.

Grading:

The course grade for this course will be determined as follows:

For ME-s	
Quizzes	10%
Design Review	15%
Proposal (written and oral)	15%
Progress reports (written and oral)	15%

Final report (written and oral)	20%
Project Implementation	25%
Total	100%

-50% Failure to pass FE exam

For EE's	
Professional Service	10%
Quizzes	10%
Design Review	10%
Proposal (written and oral)	15%
Progress reports (written and oral)	15%
Final report (written and oral)	20%
Project Implementation	20%
Total	100%

-50% Failure to pass FE exam

Project team members are also asked to evaluate each other's performance periodically and at the completion of the project. If any team member receives unsatisfactory performance evaluations from all other members of the project team he/she is subject to receiving an "F" in the course.

Fundamentals of Engineering Exam (FE):

The senior design project course is used (in part) to ensure that students prepare for the Fundamentals of Engineering Exam (FE). Successful completion of the FE or the EE/ME department's version of the FE is required to obtain a passing grade in the course. A number of books are available in the bookstore to assist in preparation for the FE exam. Videotapes on the different topics are also available from IEEE through the student branch. The College of Engineering usually offers study sessions in the fall and spring.

Professional Service:

Professional responsibility includes activities such as attendance at professional society meetings, technical presentations, departmental activities, etc. Professional service is an important ingredient in all professions. All professional service points must be completed at least one week prior to finals.

Sample Projects

As mentioned previously, the projects for the course come from industry, research efforts and other faculty initiatives. Some projects may last for only one semester while other projects are considered on-going which means they may last for several years with each assigned project team completing a portion of the overall project. Some projects require both EE and ME students while others may require only EE or only ME students. However, the reporting subsections of the class are always mixed so that all students see both EE and ME

type problems and solutions. The number of students working on a particular project also varies considerably. As an example, some of the projects assigned for the Fall Semester of 1998 were:

Aircraft flight simulator (1 EE, 1 ME)
Distributed power generation system (1 EE, 1 ME)
Obstacle detection and avoidance system (3 EE)
Characterization of the mechanical wear of an alternator (2 ME)
Automated CD ROM test loader (2 EE, 2 ME)
Cotton fiber impedance measurements (1 EE, 1 ME)
Fuel cell powered electric car (5 EE, 8 ME)

Results

As might be expected, some students resist doing something considerably different than they have done before. However, they usually adapt very well a few weeks into the semester. The benefits of the interdisciplinary efforts really show up on some of the projects and don't on others. Since the students get to see presentations on a number of different projects they also get to see these results. Students are frequently surprised when they are able to contribute to parts of an engineering project that they may feel is outside of their field. The students seem to enjoy working on "real world" problems that are not artificially constrained to fit into a specific discipline. Interestingly, some students have backgrounds that allow them to cross over from one discipline to another. On one project the best welder was an EE. On another project, most of the software was written by a ME and some mechanical design was done by an EE.

The most difficult part of the course is keeping the projects on track and on time, which is exactly the same problem in industry. The matrix management structure makes this more difficult since the faculty or industry advisors are, frequently, not directly associated with the course. The benefits of having projects from many different sources allows for a great variety of very interesting pertinent problems. It is very important to maintain communication with the advisors.

The students tend to complain the most about the presentations and the lectures. Explaining the reasoning behind the processes and procedures has helped considerably.

Conclusions

Based on the experiences of the past four academic years, the multidisciplinary senior design course at Texas Tech has been consider a success by the participating faculty and students. Of course, problems do exist and continual changes are being made to improve the program. As to be expected, a number of projects have been outstanding successes and some have been failures. However, the goals of the program are being met and the students are gaining a real appreciation for multidisciplinary nature of real engineering problems.

The advanced vehicle research projects have stimulated significant student

interest and involvement. Much of the College of Engineering's success in achieving *real* multidisciplinary education is credited to these projects. As an additional benefit, a number of additional funded research programs have been generated from the senior multidisciplinary vehicle projects.

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Darrell L. Vines is well known in electrical engineering education. His long and distinguished association with the IEEE Education Society led to a Meritorious Service Award in 1990. Dr. Vines has worked extensively and published on the interdisciplinary project laboratory over the last several years. He has also been a researcher on the advanced vehicle research team at Texas Tech University.

Timothy T. Maxwell joined the Mechanical Engineering Department faculty at Texas Tech University in 1984 and has been involved in vehicle research for over 15 years. He is presently involved in several research projects related to vehicles/engines and is co-author of a popular alternative fuels research. Dr. Maxwell has been an advisor for all the TTU teams competing in alternative fuels competitions since 1989.

Jesse C. Jones has been involved in facilities, systems, and component design for over 40 years. He was an engineering manager for NASA for over 20 years before coming to the ME Department at TTU in 1982. He was one of the leaders in establishing the multidisciplinary senior design course presently taught at TTU. He is co-author of a widely used design textbook and a popular fuels reference textbook.