Program for Multidisciplinary Engineering Projects

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Abstract

This paper describes a multidisciplinary capstone engineering design course utilizing projects from industry, research programs, and other faculty initiatives. The program involves electrical and mechanical engineering students at Texas Tech University and is team taught by both departments. The structure of the program along with example projects and results is presented.

Introduction

All undergraduate engineering education programs need to provide for design experience. However, the approach used to provide the experience varies considerably at different institutions. At Texas Tech University, the Departments of Electrical and Mechanical Engineering have provided this experience through separate, independent project design courses for many years[1-5]. Every effort was made to have these projects related to current up-to-date topics and to be relevant to state-of-the-art industrial practices. Both programs used projects proposed from industry, researchers throughout the university and medical school, departmental research activities, and other faculty initiatives. These projects were, for the most part, complex, long term, and open-ended. Since these projects were practical, real-world projects they frequently involved areas outside traditional engineering disciplines. These projects have proven to be very beneficial to students, but have shown that a fully integrated multi-disciplinary capstone design course sequence could be of even greater benefit. A number of other engineering faculty through out the US have come to similar conclusions[6-11].

To address this issue, the Electrical and Mechanical Engineering Departments at Texas Tech University, during the fall semester of 1994, initiated a formal multidisciplinary capstone design project program. As in the past, this program utilizes projects from industry, College of Engineering and other research efforts and other faculty initiatives. All of the projects require design and development. This program was 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 goals of this program are: a) to develop an understanding of engineering design projects from recognition of a need and definition of objectives through completion of the project, b) to foster student creativity, c) to broaden the student's concept of engineering problems to include all engineering disciplines and other non-engineering factors that have an impact on the final problem solution, d) to provide a unique educational experience for students on project teams and e) to enhance the student's communication skills.

Program Structure

The two courses are multidisciplinary and include both electrical and mechanical engineering students. Lectures are presented by faculty from the Electrical and Mechanical Engineering Departments. The lectures cover subjects including proposal preparation, the design process, management of design projects, design analysis for material selection, statistical decision making in design, safety and environmental protection, oral communications, and engineering ethics. Much of the material covered during the lecture is taken from the textbook, "The Engineering Design Process", by Ertas and Jones, and other appropriate references. Experts from industry also serve as guest lecturers.

Homework is assigned, as appropriate, to give students some experience in applying the material discussed in the lecture. Grades on the lecture portion of the course is based on class attendance, class participation, homework and tests. Two tests are given during each semester.
Projects

Projects are either one or two semesters in length, although the vast majority are two semester projects. Specific project deliverables are determined by the responsible project advisor, course instructor and laboratory director in conjunction with the student project group. A menu of projects is presented and described during the first class meeting. Students prioritize the projects they are interested in and submit a list to the course instructors. Although individual preferences are considered, all projects are assigned based upon requirements of the specific projects. There is no guarantee that anyone will be assigned to their preferred projects. Once the assignments have been made, the student project groups meet with their advisors and laboratory staff to develop project schedules and deliverables.

Reporting

For all projects, students give weekly oral progress reports. These oral reports are presented by the project team with each student reporting on the portion of the project for which he or she is responsible. This is one of the primary ways in which each student’s effort on the project is evaluated. Oral progress reports must include:

1) status of each individual member’s weekly deliverables,
2) technical details on the project (diagrams, flow charts, schematics, design decisions, parts selection, etc.),
3) accomplishments during the week,
4) updated project schedule with changes indicated,
5) deliverables and effort scheduled for the upcoming week,
6) identification of problems for which assistance is needed,
7) updated budget with changes indicated,
8) indication that project advisor has approved the progress report.

The oral presentation must be well organized and include visuals. These presentations constitute small design reviews and must contain enough technical information for students and instructors to fully understand the direction of the project. After the team completes their presentation, the faculty and students in the class ask questions related to the project. All team members are equally responsible for answering questions following the presentation.

A written progress report is also required weekly identifying progress for the past week as well as problems encountered, and outlining plans for the upcoming week. The student teams are required to meet with their project advisor to discuss these weekly progress reports and have the advisor sign the report. These signed, written progress reports are due each week at the beginning of the lecture period. This procedure insures continual contact between the teams and their advisors.

Each team member also keeps a project notebook. This notebook is turned in at the completion of the project. All project related work is kept in this notebook. The notebook is used as a partial measure of the work accomplished on the project by the team member.

Written proposals are prepared for new projects and oral presentations are made describing the proposed approach, budget requirements and schedule for completing the work. Final oral presentations and written reports are also submitted upon completion of the project.

Grading

The course grade for this course is determined from tests, proposal (written and oral), progress reports (written and oral), final oral presentation, final written report and advisor’s evaluation. Project team members are also asked to evaluate each others’ performance at the completion of the project. If any team member receives unsatisfactory performance evaluations from all other members of the project team he/she can be subject to receiving an “F” in the course.

Example Projects

Some of the projects assigned during the past year are shown below.

- Adsorbed natural gas storage system for automotive vehicles (ME)
- Rapid prototyping using glue gun and CNC machine (ME, EE, IE)
- Design and construction of a temperature and humidity controlled peanut drying bin (EE, ME)
- Design, development and fabrication of a gravel drying system for Lubbock State School (EE, ME)
- Automated walking machine (EE, ME)
- Hybrid electrical vehicle (Escort) (EE, ME)
- Hybrid electrical vehicle (Neon) (EE, ME)
• Design and development of an optimized propane fueled vehicle (EE, ME)
• Real time speech recognition system (EE, ME)
• EEG evoked potential analysis (EE)
• Solar-assisted, electric go-cart (EE, ME)
• Optical characterization of textile fibers (EE)
• TX space grant rover design project (EE, ME)
• High speed imaging (EE, ME)
• Patented hot fuel-injection system to improve fuel vaporization, combustion, exhaust emissions and economy (ME).
• Airfoils for wind turbines (ME)
• Desmodronic variable valve timing device (ME)

No attempt is made to artificially make projects multidisciplinary. Project advisors frequently have mixed teams to advise. For large classes, the lectures are held together and the presentation sessions are broken up into smaller groups. All presentation sessions have a mixture of ME and EE students and faculty and all students are expected to actively participate in all of the presentations. Thus, even though some students may not be on multidisciplinary projects, all of the students are exposed to a wide variety of multidisciplinary projects.

One particular project in the '94-'95 school year is an excellent example of what an interdisciplinary project can be. The project, Neon Hybrid Electric Vehicle, had a team of 15 students with an almost equal mix of EE and ME students. Actually, the students worked until mid-June (approximately five weeks after the end of the spring semester) to complete the project. Although the project team was large, the students did an outstanding job of integrating their efforts and coming together as a truly effective working unit. The project involved essentially all aspects of automobile subsystems design and fabrication including internal combustion engine (ICE), fuel metering and control, vehicle (ICE/electric motor) control, structures, fluid systems, heating and air conditioning, vehicle suspension, transmission, brakes, electrical systems and electronics. The vehicle participated in the 1995 Hybrid Electric Vehicle Challenge held at the Chrysler Technology Center in Auburn Hills, Michigan, and placed second overall with best dynamometer energy efficiency, best acceleration, best dynamic performance and most efficient zero emission vehicle. This achievement further attests to the effectiveness and commitment of the project team.

Conclusions

Based on the experiences of the past two academic years, the multidisciplinary senior design course at Texas Tech has been considered 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.

References