Nine Years of Freshman Design Projects at Mercer University

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Introduction

For the past nine years, the Mercer University School of Engineering has required freshman engineering students to enroll in a three-quarter freshman engineering sequence: EGR 101, 102, and 103. In EGR 101 and EGR 102 students are taught basic visualization skills and engineering drawing techniques. They learn to use WordPerfect, Lotus 123, and AutoCAD. They work in teams to deliver a brief oral presentation on a technical topic. In EGR 103, the students build on the skills they learned in EGR 101 and EGR 102 in order to design, build and test a simple device. The focus of this paper is an evaluation of a number of the projects that have been used in the EGR 103 design course.

Course Description

The overall objective of EGR 103 is to introduce engineering students to the design process. In this class, students form teams and work together to design a simple device which meets the needs expressed by a client. The client, who is usually not the course instructor, describes the project and approves designs. The course instructor lectures on various aspects of the design process, defines project milestones, monitors the teams' progress and assigns grades.

Although the teams must produce a working prototype, the emphasis is on the process rather than the product. During the first half of the course, teams work together to define the problem, develop alternative solutions, define merit criteria, and propose a solution. At the midterm Preliminary Design Review, the teams present their solution and request permission to begin building their prototype. Near the end of the quarter, the teams present the Critical Design Review in which they discuss the building and testing of the prototype.

In order to make the process more realistic, students are given a budget. The school reimburses the students for the money they spend on the project, up to a pre-determined maximum (usually around $30). Teams do not receive permission to proceed to the building phase if their design exceeds the budgeted amount.

Design Project History

EGR 103 was first offered in 1988. During the early years, we offered a large variety of design projects. Since we used faculty and staff volunteers as clients, this allowed some clients to work with as many (or as few) teams as they wished. Thus more people were willing to volunteer if they were able to limit their involvement to one or two teams. Most of the projects were designed to be used in the School of Engineering. However a small number of projects were designed for handicapped children from area schools.

The projects we used in the early years (1988 - 1991) of the design course are as follows.

- Adjustable coffee cup holder for van
- Documentation holder for computer labs
- Automatic pet feeder
- Book bag for a person using crutches
- Lap counter for a swimmer
- Home recyclable system
- Automobile pet restrainer
- Chalkboard spreadsheet template
- Audible timing counter for repetitive work
- Device to allow driver to check trailer tail lights
- Alarm system to awake children from a deep sleep
- Floor scooter for a child who has cerebral palsy

Table 1 includes a list of the projects we used in the Spring of 1992. By this time, the author was an instructor in the course. Therefore, this table includes the author's personal rating and comments about each project.

PROJECT DESCRIPTION	RATING	COMMENTS
Auxiliary view training aid	Good	We still use it in our graphics course
Drawing room equipment organizer	Good	We still use these organizers, more expensive due to the quantity of wood required, mature students chosen for this project
Multiple can crusher	Poor	None of the prototypes were effective
Dorm room alarm	Fair	Requires knowledge of electronics
Home recycling center	Good	Simple concept
People counter to monitor students entering computer lab	Fair	Requires extensive knowledge of electronics
12v to 6v voltage divider	Fair	Requires knowledge of electronics
Transparency magnifier for overhead projectors	Fair	Inexpensive, but too simple
Devices for rehabilitation clients: Eye tracker Head control monitor Drop ball game	Fair	Creative solutions possible, but ethical and legal issues are a concern

Table 1. Spring 1992

By Spring, 1993, it was getting harder to find new projects as well as faculty willing to volunteer to be a client. Many faculty members wanted to work with only one or two teams. Since there were over forty teams, it was necessary to develop a large number of different projects. In addition, some projects were significantly more difficult than others. This caused some concern among the students. Table 2 includes a list of the projects we used in the Spring 1993 term.

PROJECT DESCRIPTION	RATING	COMMENTS
Desk drawer organizer	Good	Difficulty ranges from simple to moderately complex according to client needs
Folding bicycle carrier for pickup truck	Fair	Can be expensive
Tool caddie	Good	Difficulty ranges from simple to moderately complex according to client needs
Work measurement station	Good	Must consult with IE faculty or use IE text
Fitt's Law device	Good	Must consult with IE faculty or use IE text
Folding stool for bathroom	Poor	Required permanent installation
Door knob attachment for person with hand impairments	Fair	Commercially available solutions
Portable dog house	Good	Can be expensive, depending on size and materials
Squirrel-proof bird feeder	Good	Many possible solutions
AC switch modification for person with hand impairments	Fair	Requires knowledge of electronics
Device to display a 4 cycle engine	Fair	Involves very little design
Knotmeter	Good	Simple principle, several design possibilities
Wind tunnel fixtures	Fair	Involves very little design

Table 2. Spring 1993

In the Spring 1994, we decided to hold a performance-oriented contest at end of the quarter. Clients were required to develop specific criteria so that a winning design could be chosen for each project. Students from each section were required to display their prototypes on the lawn outside the Engineering Building.

The contest approach had several positive effects. Students were able to compare their designs with those from other sections, possibly seeing alternatives that they had not thought of before. Knowing that they would compete with the other sections, students tended to put more effort into the construction of the prototype. Engineering faculty and administrators not directly involved in the course had an opportunity to view the projects. On the negative side, the decision to hold a contest at the end of the term made it more difficult to find possible projects. Some projects didn't seem appropriate for a competition.

We used seven different projects that quarter. Since there were over forty teams, each client was assigned five or more teams to work with. This resulted in a much larger time commitment from the volunteer faculty. Table 3 includes a list of the projects we used in Spring 1994.

PROJECT DESCRIPTION	RATING	COMMENTS
Portable solar water heater	Good	Simple principle, easily learned, trial-and-error instead of calculations
Soda-bottle rocket launcher	Fair	Easily accomplished, few design alternatives
Portable solar oven	Fair	Easily accomplished, possibly too simple
Human-powered water pump	Good	Many design alternatives, can be expensive
Water-balloon launcher	Good	Many design alternatives, potential for abuse if other projectiles are used
Wind-powered water pump	Poor	None of the teams could build a functioning prototype
Solar-powered model car	Good	Students willing to spend a lot of time designing and testing the car, solar panels are expensive

Table 3. Spring 1994

The Spring 1994 end-of-the-quarter contest was very popular with the students. Therefore, we decided to require it for the Spring 1995 class. Thus we selected a small number of projects and developed contest criteria. We held the contest on a Friday afternoon near the end of the term. We put up a tent next to the engineering building and served light refreshments. We staggered the starting times of the different contests so that the entire class could view the competitions. The course director, Jim Stumpff, even built a large, temporary trough next to the engineering building so that the solar boat teams could compete. Table 4 includes a list of the projects we used in Spring 1995.

PROJECT DESCRIPTION	RATING	COMMENTS
Thermosiphoning solar water heater	Good	Simple principle, easily learned, trial-and-error instead of calculations
Solar-powered model boat	Good	Fun project, competition requires place to float boats
Physics-principles Rube Goldberg device	Good	Lots of creative possibilities
Portable solar oven	Good	Easily accomplished, possibly too simple
Brick-maker for use by Peace Corps volunteers	Fair	Easily accomplished, possibly too simple
Human-powered air cannon	Good	Students willing to spend a lot of time designing and testing the device

Table 4. Spring 1995

During the most recent offering of EGR 103, we changed the end-of-the-term contest to an end-of-the-year display and pizza party. Faculty and staff were invited to see the projects the freshmen had designed. The students who were enrolled in the design course were given a chance to vote for the winning design for each project. The switch from a contest to a display allowed us to choose some projects that did not have a performance criterion. Table 5 lists the projects we used in Spring 1996.

PROJECT DESCRIPTION	RATING	COMMENTS
Model motor demonstration device	Good	Simple to build, easy to understand, good demo to show at high school visits
Model radio demonstration device	Good	Difficult for teams who do not have prior electronics experience, good demo to show at high school visits
Water-sampling device for Adopt-a-Stream Project	Good	Many alternatives, increases awareness of environmental issues
Shoe-tying device for one-handed person	Fair	Inexpensive, but few alternatives
Burglar alarm demonstration device	Fair	Difficult for teams who do not have prior electronics experience, parts must be ordered, possible delays
Water-powered Rube Goldberg device	Good	Encourages creative solutions, fun

Table 5. Spring 1996

Discussion

The EGR 103 course has been a success since its inception. However, we have learned some valuable lessons in the past nine years.

1.We no longer use clients from outside the School of Engineering. Allowing an outside agent to use a product designed and built by a team of students raises liability issues.

2.Course instructors need to carefully monitor the teams' progress during the early stages of the design process. Sometimes teams develop "tunnel vision" through which they can see only one solution. Classroom activities should be structured so that the teams are required to develop several varied alternatives. Students should not be allowed to begin building before they have had sufficient time to develop and assess a variety of solutions.

3.Electronic projects need to be carefully selected. They frequently require advanced knowledge, parts fail and must be replaced, and time for testing can be a serious constraint.

4.When choosing a possible project, it is better to err on side of too easy than too difficult. Students learn a lot about teamwork, meeting deadlines, and the basic design process even when they design and build a relatively simple device.

5.An end-of-the-term contest/exhibit does a lot to enhance the quality of the design effort. However, it is difficult to find a sufficient number of projects that have similar time requirements and difficulty levels.

6.Even freshmen who have little engineering knowledge can be successful in this course if the project is carefully selected. Projects must be matched to the skill level of the student. Projects must be simple enough so that they can be completed within the time frame. They must be complex enough that each member of the team has a chance to make a significant contribution.

Conclusion

The freshman design course is a valuable part of Mercer's freshman engineering sequence. The course gives students an opportunity to learn about the process of design as well as the art of working together in a team. The freshman design course helps students to see that engineering can be fun as well as challenging. In fact, many students tell us that this course helped them confirm their choice of engineering as a career.

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