Session 2323

An Interdisciplinary Junior Level Team Design Experience in Engineering

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Abstract

The course (EN3222, Design Laboratory, two semester hours, spring semester) described in this paper was initiated in the spring of 1992 at John Brown University to provide students with design-cycle experience and interdisciplinary team activities. Typically the teams of this course are formed with three students of engineering and two students of graphic design. Each team forms a company which is then asked to respond to a Request For Proposal from "investors" for a consumer product design appropriate to one of five consumer markets. The engineers on the team work on the technical design, computer drawings, Failure Mode and Effects Analysis, reliability studies, economic analysis, testing; and consulted on the case design and technical manual content. The graphic designers work on the company identity, advertising layouts, marketing plan, web-page design, case design, manual design and packaging. Five design seminars are presented by the faculty team. Four design reviews are conducted with each team during the semester. The final presentation by the team before the "investors" includes a demonstration of the working prototype and the presentation of all documentation and marketing elements. Team interaction in the course has been effective though sometimes frustrating to the student. Student response to the course has been positive. The course has provided a good preparation for the full-year senior design project. The paper also discusses creativity issues, the use of computer tools, the application of reliability factors, student evaluation techniques, and some of the product designs.

"The mind is not a vessel to be filled but a fire to be kindled." Plutarch

I. Introduction

The engineering faculty at John Brown University began discussing a junior-level design laboratory in 1990. Students were spending extensive amounts of creative time in the computer room but not in the electrical or mechanical laboratories. One factor was that the labs were not open for them to do this. Another factor was that the standard lab experiments were not open-ended enough to make the students think through the project. It was necessary for the faculty to design some lab experiences that would stimulate real thought and draw students to the lab to confirm their ideas. It was also necessary for the labs to be open when students wanted to work there.

The faculty was concerned that students were not well prepared for entering into the senior design experience. Since 1977, a full-year senior capstone experience has been required for all engineering students. Since 1985, most of these projects have been in cooperation with regional industries while the remaining ones have been JBU projects. The faculty felt that more could be accomplished in these projects if the students had previous experience in creative thinking, project planning, keeping a log book, searching for parts, ordering parts, meeting project schedules and in the general frustrations of the design process.

An ABET visitor suggested that it would be desirable to have some team design experiences in the design emphasis at JBU. In response, three things have been done:

1. Added two team design experiences to the freshman course, Engineering Concepts and Design.
2. Added one team design experience to the sophomore mechanical systems course.
3. Added this junior-level design lab which incorporates an interdisciplinary team experience.

These additions give the students the team exposure necessary to know the results of interaction and dependency.

At the 1991 ASEE Annual Meeting a paper authored by W.L. Cooley and jointly presented by Mr. Cooley and Richard Cloutman entitled "Electronic Engineering Design Education - A UK Perspective" [1] described an interdisciplinary team design experience undertaken by students at the Hatfield Polytechnic and the Hertfordshire College of Art and Design in the United Kingdom. Engineering students and graphic design students were teamed to do a real product design. The course offerings at JBU provide the basis for similar cooperation in product design.

Therefore, in order to promote more lab time, provide preparation for the senior design project, provide an additional team experience and make that team experience interdisciplinary; the faculty introduced "Design Laboratory" into the engineering curriculum in the spring of 1992. The course is required of all engineering majors. This paper describes the engineering elements of this course.

II. Objectives of the Design Laboratory

The objectives of the course are:

- Give the student a practical experience with a realistic consumer product design.
- Enable the student to experience the design cycle.
- Provide the experience of working with an interdisciplinary team.
- Require the student to meet a design schedule.
- Require the student to keep a log book (engineering notebook).
- Provide exposure to aesthetic and ergonomic factors in design.
- Require the student to give consideration to product safety and reliability.

- Show the student appropriate documentation procedures.
- Provide opportunity for oral and written communication experiences.
- Require that the student spend more time in the laboratory.
- Provide experiences applicable to the senior design project.

III. Course Description

This course has brought together students from the Art and Design Department who are taking a second course in Graphic Design and the engineering students enrolled in EN 3222, Design Laboratory. Teams of two graphic-design students and two or three engineering students were formed to work on a major design project. These teams responded to a Request For Proposal (RFP); proposed a prototype of a consumer product appropriate to one of five consumer markets; designed the product and presented the operational prototype, drawings, manuals, case design and marketing plan to a group of "investors."

The engineers on the team worked on the technical design, computer drawings, Failure Mode and Effects Analysis (FMEA), reliability studies, economic analysis, testing; and consulted on the case design and technical manual content. The graphic designers worked on the company identity, proposal graphics, case design, manual design, packaging, advertising layouts, marketing plan and web-page design.

During the first six weeks of the course the engineers, in teams of two, worked concurrently on a minor design project in order to give them prototyping experience. This effort took place while the engineering students were preparing the proposal for the major project with the graphic designers.

The textbook being used by the engineers is <u>Total Design</u> [2]. These students also had available from previous courses two references, <u>Design of Devices and Systems</u> [3] and <u>The Universal Traveler</u>[4], a book on creativity.

Five design seminars were given in the course covering the topics of creativity, needs analysis and design specifications, project planning and scheduling, Quality Function Deployment (QFD), proposals, documentation, design reviews, Failure Modes and Effects Analysis, reliability and testing.

Handouts were available on the RFP, system design procedures, QFD, documentation, project scheduling and reliability. The reliability notes were obtained from Bill Kuriger in the School of Electrical Engineering and Computer Science at the University of Oklahoma [5]. Other reliability reference material was made available from the Reliability Analysis Center of the Rome Laboratory [6].

Written documents required during the course included a proposal in response to the RFP, a project scheduling diagram, the final report and an Owner's Manual.

Engineering notebooks were checked periodically. Suggestions were made concerning the character of the entries to be made in the notebooks.

Oral presentations included four team design reviews and the final team report to the class, the "investors" and invited guests. The engineering instructor and the graphic arts instructor conducted the design reviews with each team, in a seminar room.

Computer work included project scheduling, electric circuit simulation, schematic capture, mechanical drawings, and renderings. The computer tools have included Microsoft Project, Claris Impact, AutoCAD, Solid Edge, Working Model, JP System 5, Electronics Workbench and ORCAD.

A course schedule is shown in the Appendix.

IV. Design Project Specifications

The minor design project was selected by the teams of two engineers from a list like that shown below.

- Design and build a simple device to measure the specific heat of liquids.
- Design an improvement in backpacking equipment.
- Design a piece of survival equipment.
- Design a new toy for children 6 to 60.
- Design a jiglike device that an amateur “do-it-yourself” home workman could use to lay up an acceptable straight brick wall.
- Design a liquid-level indicator to measure the level of water in a cylindrical tank.
- Design a better can opener.
- Design a fishing lure that will stay at any preset depth.
- Design a specialty tape dispenser (lengths, sizes, shapes).
- Design a new type of cutting tool.
- Design a sandpaper holder.
- Design a new type of electrical extension cord.
- Design a tarp clip.

The team was to design and build the item with parts cost not to exceed $25, record appropriate information in their engineering notebooks (log book) and present the working prototype to the engineering students of the class and invited engineering faculty. No formal design reviews or written work were required for this project.

The major design project was to investigate the possibility of entering the market with a consumer product. It was assumed that the design team had done a market study and decided that the most likely sectors for a successful entry would be in one of these five areas.

- Sports and leisure technology
- Home technology

- Environmental technology
- Transportation technology (automobile, bicycle, pedestrian)
- Rehabilitation/special education technology

The student team was required to identify a potential product from one of these five areas that was not currently available. A prototype of this product was to be built.

A project schedule was to be produced using tools such as Microsoft Project, MacProject Pro or Claris Impact. The team project schedule was referenced in all design reviews as the team proceeded through the engineering efforts of problem definition, ideation, specification, simulation, prototype construction, testing and documentation, and the graphic design efforts of company identity, case design, package design, manual design and advertising.

The team was to produce a set of supporting documents for the prototype product. These documents included complete product design specifications, computer generated schematics and renderings, an Owner's Manual, and a final written report of the work including safety and reliability studies and an economic analysis.

Additionally the team was to produce a sample package for the product and at least two advertising compositions along with a marketing plan.

V. Team Designs - 1998

The 1998 course involved five design teams. The prototypes developed were as follows:

- SWIVEL & SHOOT by Paragon Technologies. A new camera mount for tripods which is more flexible and also simple to operate.
- SUNBURST by Pyramid Concepts. An alarm-clock lamp with additional outlet receptacle.
- AUTOCHEF by MPEG Appliances. An automatic stirring unit for continuous stirring of soups, stews and sauces while they cook.
- SMART BURNER by Home Safety Systems. An add-on device to turn off a kitchen range heating element or gas burner if there is no pan on the unit.
- GENIUS by Kouan Inc. An automatically controlled, personalized space heating/cooling system.

VI. Student Evaluation Tools

An itemized proposal evaluation provided feedback on the written proposal. The proposals have been about ten pages long. The students used previous proposals as examples. An itemized oral presentation evaluation was used at one of the design reviews and for the final presentation.

At the end of the course each student evaluated the contributions of the other members of that student's team. The completed evaluation forms were tallied by a disinterested third party and the results given to the engineering instructor.

VII. Grading Procedure

The final grade in this course (the engineering course) was determined in three parts. One part came from points the individual earned in keeping the engineering notebook and a faculty and team judgement of the particular team member's contribution to the team.

The second part came from points earned by the two-person engineering team in designing and presenting the minor project.

The third part came from points the team earned on the major project. Each member of the team received the same points for their joint effort in producing a project schedule, writing the proposal, performance in design reviews and oral presentations, preparing the written report and the manual, developing the prototype design and producing schematics and renderings.

VIII. Student Response

Student response has been generally good since this course was initiated. In post-course evaluations the students have given high marks to knowledge acquisition, intellectual stimulation, learning to do design, learning how to get design information, laboratory work, helping each other and promoting interest in design. Reactions have been mixed on how effectively the teams worked together, the contributions of various team members, whether the objectives of the course were met and the subjective nature of the evaluations made of their work. Open-ended work tends to be frustrating to many students who like a structured course environment. Several students have indicated a need for more help in making oral presentations. A more deliberate effort to do this is underway. The students also wanted more feedback on grade determination. Some students felt that the prerequisites for the course were inadequate. Most students felt the course was too much work for two hours credit, but still seemed to enjoy the course.

To the designers and instructors of this course, it seems appropriate that the students should experience some frustration working in their teams and with the evaluations. One comment was "I felt that working with other students was unfair because the students were not allowed to learn as effectively as (they would) if they were to work on their own." This is exactly the environment they need to experience. Non-cooperative behavior, contradistinctory ideas, compromise, schedule delays, working together to meet deadlines and subjective evaluations are all desirable factors for these students to experience before they enter the senior capstone course and ultimately their careers.

IX. Conclusions

This laboratory experience develops team work, stimulates laboratory activity and provides for a meaningful design experience. All the objectives outlined for this course are being met to some degree. The course has now been offered for seven years and has evolved each year. The written materials (books and handouts) are essentially the same. Better feedback on oral presentations is now being given through discussion with each group after their presentations. Peer assessment has been more recently used to give a greater spectrum of input to the grading process. A new means for students to keep up with their own grade at three week intervals will be provided in a handout listing each assessment situation, the possible score and their score.

This has been an excellent learning experience for the students in both groups (engineering and graphic design). It has also been a stimulating experience for the instructors.

Bibliography

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6. *Reliability Toolkit: Commercial Practices Edition*, Reliability Analysis Center, Rome Laboratory, Griffiss AFB, NY, 1993.

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Jim Pearson has a BEE from the University of Minnesota, 1956; an MS in mathematics from the University of Arkansas, 1962 and a Ph.D. in Electrical Engineering from the University of Arkansas, 1972. Dr. Pearson has taught engineering at JBU since 1959. His engineering experience came from IBM, 3M Company, Webb Wheel, NASA, and the Solar Energy Research Institute. He has provided engineering services in Ecuador and Pakistan.

APPENDIX

EN 3222 SCHEDULE - 1998

Week	Activity
1	Syllabus and minor and major project descriptions Design Seminar 1
2	Design Seminar 2 Critique project ideas Prepare proposal draft
3	Design Seminar 3 Working session
4	Design Seminar 4 Working session Timetable
5	Design review Visual identity, timetable proposal, block diagrams, specifications
6	Presentation of minor project
7	Oral progress reports Product-feasibility/ marketability, project plan, project progress
8	Design Seminar 5
9	Design review Circuit design, mechanical design, FMEA, prototyping, difficulties, manual
10	Working session Mechanical and electrical layout Case design/fabrication
11	Working session Manual drafts Reliability study
12	Working session Renderings PCB board work Integration
13	Working session
14	Design review Progress, case drawing/ prototype, manual, circuit board, reliability
15	Final preparations for presentation
16	Final presentation - full documentation for assessment; prototype, oral report, written report, manual, packaging and marketing information.

EN 3222 DESIGN SEMINARS Spring 1998

Design Seminar 1
- Total Design
- Design Motivation
- Creativity and Christianity
- Creative Activity
- The Design of Everyday Things

Design Seminar 2
- Getting Ideas/Need Analysis
- Quality Function Deployment
- Product Design Specifications
- Using a Project Scheduler
- Using Laboratory Notebooks
- Using Freehand, Pagemaker, Photoshop, Illustrator and Quark Xpress

Design Seminar 3
- Marketing Factors
- Design Reviews
- The Proposal
- Oral Presentations

Design Seminar 4
- Manuel
- Documentation

Design Seminar 5
- Reliability
- FMEA
- ORCAD