Innovations in Freshman Mechanical Engineering Curriculum at NJIT.

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Abstract: This paper describes the Mechanical Engineering contents of a new inter-disciplinary, project-based freshman engineering curriculum at NJIT. The course, which was run as a pilot during the 1996-97 academic year, is called Fundamentals of Engineering and has been now been approved for the freshman engineering curriculum. The two case-study projects, which constitute the Mechanical Engineering component of the course curriculum, are the "Lawn Sprinkler" and "3.5″ Floppy Disk Drive". In this course, the freshman engineering student is introduced to many aspects of engineering as an entire unit working together, with particular emphasis on the concept of teamwork in engineering research projects. Students are introduced to many computer aided design tools available at NJIT which can be used not only to build models of the product to be manufactured but also for diagnostic analysis in order to solve potential manufacturing problems. The student is also introduced to the concept of communication among team members and the concept of technical report writing and oral presentation. The grading and course evaluation schemes are also discussed. A few samples of students' graphic communications are reproduced.

Keywords: freshman engineering curriculum, innovations, projects, reverse engineering.

Introduction

During the Summer of 1996, from May to the end of August a number of professors from several Departments within NJIT, met to develop a new freshman engineering curriculum based on a previously prepared course outline. This new course, known as Fundamentals of Engineering (FE), is a follow-up to the existing NSF-sponsored Gateway Coalition Course called Fundamentals of Engineering Design (FED) which had run for more than three years. FE is an interdisciplinary project-based course consisting of design and computer applications components. The students in FE work as a team on a number of case-study projects designed to introduce the freshman engineering student to a range of the fundamental concepts of engineering. In this context, the student is exposed to a wide range of engineering disciplines and applications. The rationale behind this approach is that through multiple exposures to the fundamental concepts and their integration in different contexts, the student will develop a strong grasp of the breadth of engineering and provide a road map to their future studies

This article describes the Mechanical Engineering component of two of the four projects that constitute the curriculum for the 1996-97 Fall and Spring semesters, and the rationale behind the course content. It begins with the course structure, followed by a detailed description of the mechanical engineering contents of the two projects, including the grading and course evaluation schemes used.

The Course Structure

The Fundamentals of Engineering freshman course is a project-based two semester curriculum modeled on the NSF-sponsored Gateway Coalition Course; the latter known as Fundamentals of Engineering Design had run parallel with the FE pilot course, described in this paper, but is now replaced entirely by FE. The FE pilot course has two main components: a fundamentals of engineering component and a computer application or computer aided design (CAD) component. Furthermore, each project is paired with a freshman course from the department of Humanities and Social Science (HSS) where the faculty involved advises the students on the preparation of project reports and the dynamics of oral presentation, the latter being one of the many components of the curriculum. About 16 to 20 students work on each project with faculty from the various Departments acting as advisors or project "facilatators". There is no formal lecture in the conventional sense. For each project, the students are divided into teams of between 4 and 5 students per team. There were a total of nine departments involved in the pilot course, seven of these falling

under the umbrella of Newark College of Engineering (N.C.E.). The course numbers, the titles of the four projects, the Departments and faculty involved in the Fall 1996 semester are shown in Table 1.

Table 1. The departments and faculty involved with the FE pilot course for the 1996 Fall.

Section	Project	Department	Professor
FE-101-007 paired with HSS-101-003	Lawn Sprinkler	M.E. I.M.E. Comp. Appl. HUM	K.A. Narh, H. Surjanhata P. Ranky G. Milano R. Friedman
FE-101-103 paired with HSS-101-019	Emergency Medical Service Field Radio	E.C.E. BME Comp. Appl. HUM	M. Sosnowski,, J. Strano S. Reisman L. Jones D. Simmons
FE-019 paired with HSS-101-025	Floppy Disk Drive	M.E. E.C.E. Comp. Appl. HUM	K.A. Narh, H. Surjanhata M. Sosnowski, J. Strano H. Assadipour R. Friedman
FE-101-023 paired with HSS-101-005	Waste Treatment Facility	ChE C.E. E.C.E. Comp. Appl. HUM.	A. Perna, D. Hanesian G. Golub H-N Hsien H. Assadipour D. Power

Course Objectives

The main objectives of the course can be summarized as follows:

- to introduce the freshman engineering student to many aspects of engineering as an entire unit working together, with emphasis on the concept of teamwork in engineering research projects;
- to introduce the student to the computer aided design tools available at NJIT which can be used not only to build models of the product to be manufactured but also for diagnostic analysis in order to solve potential manufacturing problems;
- to develop communication skills for team activities;
- to provide formal instruction on technical report writing and oral presentation, and have them practice and develop those skills.

The two projects, ' Lawn Sprinkler' and ' 3.5″ Floppy Disk Drive' were chosen because they have the potential of incorporating all the concepts outlined above. Because of the similarities in the mechanical engineering components of these projects, only one project, the lawn sprinkler will be described in detail; any substantial differences that appeared between the two projects will be pointed out.

Description of Projects

The Lawn Sprinkler Project (FE-101-007)

The specific lawn sprinkler chosen for this project is the Nelson Rainshower 40 shown in Fig. 1. The sprinkler is used to sprinkle water on a lawn using a dial mechanism. The dial mechanisms on the sprinkler can be adjusted to oscillate a spray tube according to the selected pattern of coverage. Thus, the pattern of coverage can be controlled.

The drive mechanism for the sprinkler consists of a turbine connected directly to a system of spur gears. No extra source of power is needed because the turbine drive mechanism is driven by water pressure. As the water enters the sprinkler, it goes through a nozzle directed to the turbine blades, drives a turbine at high speed, and enters a spray tube. The speed of turbine is then reduced by a spur gear system that drives a heart shaped cam at low speed. The cam moves the crank slot mechanism that oscillates the spray tube slowly. More than 90% of this particular lawn sprinkler is made of plastics, with the only metal component being the spray tube and the screws holding the various components. Most of the plastic components were injection molded; the final product was, presumably melt (spin) welded.

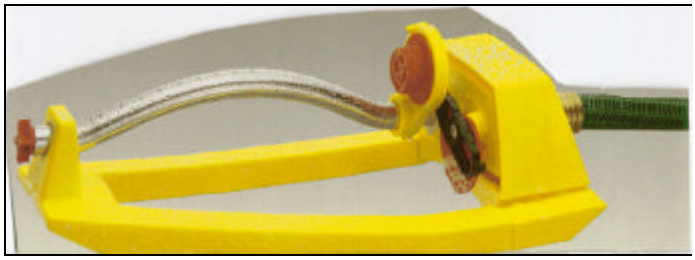


Figure 1. Nelson Rainshower®40 lawn sprinkler - Courtesy of L.R. Nelson Corporation.

The 3.5² Floppy Disk Drive Project (FE 101-019)

The floppy disk drive has read/write capability, and uses electromagnetism to "write" or store programs and data. Basically, it is used to transfer information from a 3.5" diskette to the central processing unit (CPU) of a computer and vice versa. The media located inside the diskette is coated with a magnetic material that can record data. The read/write heads, which are tiny electromagnets, use magnetic pulses to change the polarity of metallic particles embedded in the disk's coating. The heads convert electric code signals from the computer into magnetic codes recorded on the surface of the disk; the drive then reverses this process to "read" the disk. A disk drive contains two small electric motors - a spindle motor to spin the disk at high speed and a stepper motor to move the magnetic read/write heads radially across the diskette's surface. When the computer system needs to access data on the diskette, the read/write heads are stepped by signals generated by the computer system's floppy controller. The floppy drive has about eight major components composed of plastics and metals.

Project Objectives

In order to fulfill the curriculum requirements for this course, the following project objectives were set out: Students should understand the dynamics of the team approach to the design and manufacture of the product. They should also understand the mechanisms involved in the operation of a lawn sprinkler system or floppy disk drive. They would also learn about the multidisciplinary nature of the components of the products they are working with. In order to achieve this, they were required to disassemble their product, analyze it for design, function and choice of materials. They were also expected to propose a design improvement with consideration of materials, environmental impact and manufacturing process for the product. In this regard, students will also be learning, indirectly, the fundamentals of **reverse engineering**. Furthermore, students were expected to carry out CAD drawings of some of the product components, such as the spur gear of the lawn sprinkler or the front panel of the floppy disk drive. Analysis using mathematical software such as Mathcad [1] of gear dimensions and ratios (spring functions for those working with floppy disk drive) were also to be carried out. Finally, the manufacturability of the part so designed was to be assessed through the use of a computer aided engineering (CAE) software. This last part of the project was limited to mold cavity filling analysis for the plastic component [2].

In order to achieve all these objectives and at the same time insure that students were not overwhelmed by the work load, a well structured course syllabus was developed, which incorporates homework assignments to act as immediate feedback from the students [3].

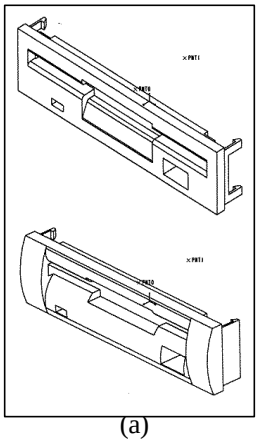
Homework Assignments

The homework assignments were based almost entirely on the topics discussed in class. Assignments consist of either a group mini report or an individual effort. As an example of a mini group report each team was asked to write a short report, using a word processor, to describe how the product for the project works - including a description of

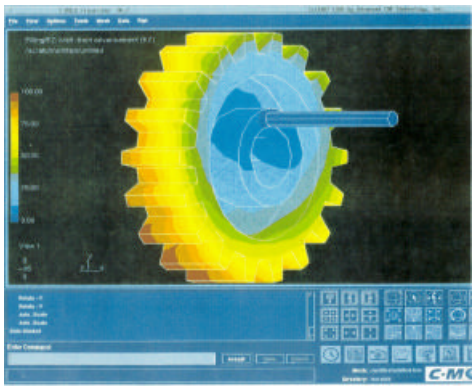
the materials used in the product. The report must be organized to include a title page, an abstract, a three-dimensional (free-hand) sketch of the product, a discussion of the function of each component part, and suggestions on any design improvements. On the other hand, assignments developed to evaluate the grasp of individual student on a particular issue discussed during the class session, might, for example, require the students to perform simple mathematical calculations, plot graphs, with Mathcad - using the measurements taken in class.

Student Learning Outcomes

Figure 2 (a and b) illustrates two samples of the results from a selected Project Report. The objective here is to use commercially available computer aided design (CAD) [4,5] and computer aided engineering (CAE) software [2] to perform a simple task, including 3-D drawing (Fig. 2a) and process analysis (Fig. 2b).



(a)



(b)

Figure 2. (a) Pro/ENGINEER® [4] generated floppy drive front panel – students' models. The lower model represents the team's design improvement of the panels. (b) Melt front advancement results from C-MOLD™ analysis [2] - students' model analysis.

The Grading Scheme

There was no formal examination for this course and the grade for the semester is a composite of grades from four main categories: oral presentation, final project report, homework assignments (including quizzes), and software applications. Table. 2a –summarizes the grading scheme for various components of the course. Table 2b shows the distribution of grades for the final project report, based on a project report format previously reviewed with the students. The assessment for oral presentation was based on a format prepared by the Department of Humanity and Social Science. Since the emphasis in this course was on team work, the rating of the presentation was based mainly on team effort.

Course Evaluation Methodology

Four methods have been used to evaluate the impact of the FE pilot course on the students. These were 1) an interview survey of all the students participating in the pilot run, 2) Team Developer™ survey, 3) standard teacher evaluation, and 4) project evaluation. The evaluation procedures for three of the four schemes listed in 1) - 4) are controlled by the office of the Dean of Engineering with most of the methodology prepared by the department of Humanity and Social Science (HSS). The project reports were evaluated in accordance with guidelines given to the students by the team advisors, shown in Table 2a. The project reports were regarded as strictly team effort and was evaluated as such. Each report was rated for both technical and grammar. The evaluation procedures will now be described.

Table 2a. The grading scheme.

Course Component	Grades Allocation (%)
Final Project Report	30
Oral Presentation	30
Design Assignments	20
Software Applications	20

Table 2b. Grade distribution for project reports

Title:	Grades Allocation (%)
Table of Contents	5
Abstract	10
Introduction	20
Design Process	15
Software Applications	10
Conclusions	10
Recommendations	10
References	5
Appendix	15

The Interview Survey

As part of the evaluation process, toward the end of the semester, students were interviewed. The purpose of this interview is to obtain the facts – directly from the students, what type of skills he/she has developed or acquired by taking this course. The interview questions covered analytical, communication, project management, researching information, team works, science and math, and computer skills.

Team Developerä Survey

In the Team Developer™ survey, each student was given a 3.5" floppy disk with survey questions which require the student to rate him/herself and his/her team members on their project. This floppy disk was distributed toward the end of the semester. The disk was created by Assessment Alternatives, Inc. of Florham Park, New Jersey. This survey is confidential in that a student is not only evaluating his or her performance but also 'peer reviewing' the team members. Regarding the other two methods used for course evaluations, instructor evaluation by the student and project evaluation by the instructor, suffice to say that the former used a standard NJIT format while the latter has already been discussed in the present section.

Discussion and Conclusions

The impact of the mechanical engineering projects within the entire freshman engineering curriculum is difficult to evaluate since only a limited number of students participated. However, all the students who participated in the two project-based course modules have successfully used all the software they were introduced to in 1) writing a simple report, 2) drawing 3-D models of the selected component parts of their product, and 3) performing simple mathematical calculations, and plotting graphs. Because of space restrictions, only two students' sample results are shown in this paper (other examples are shown in ref. 3). However, judging solely from all the students' sample results and the student feedback (not reproduced in this report), and bearing in mind that most of these students had no prior exposure to any engineering training, it appears the mechanical engineering projects have achieved its initials goals of introducing the freshman engineering student to the use of CAD and design software in early stages of their engineering training.

Acknowledgments

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