The Computer...A Real-World Engineering Tool For Freshmen

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Abstract

Two new courses which have been added to the freshman engineering curriculum to replace the traditional introductory engineering courses are discussed. These courses were designed to introduce the student to the use of the personal computer to establish a link between physical measurements, data acquisition, analysis, and the control of physical systems. The computer tools are also used in the formal presentation of results. This engineering experience will stimulate interest, reduce early attrition, and increase the attractiveness of the engineering program.

Introduction

In recent years, engineering education has come under increasing criticism from the industrial community. Reacting to this criticism, the School of Engineering Technology and Engineering at The University of Tennessee at Martin has undertaken an extensive revision of the curriculum[1]. In response to suggestions from graduates and the industrial advisory board, increased emphasis is being placed on communication skills and experience in working as a member of a design team. Although initiated before the release of a 1994 ASEE report 2, the new program parallels the recommendations contained in the report. Ideas from Keen [3] and a March 1995 workshop [4] are being incorporated into a two-course freshman sequence initially offered in the 1995-96 academic year. These courses are the first of several that incorporate design projects, reports, and presentations in an effort to produce better prepared graduates.

An often heard complaint from fist and second year engineering students is "I'm studying all of this math and science-when will I get to do some engineering?" This comment maybe a clue to the cause of the high attrition rate of entering engineering students. The new two-course freshman sequence makes use of projects, laboratory experiments, and demonstrations to get the first-year students involved in engineering. The primary goals of these courses are:

- Introduce the personal computer as an engineering tool.
- Introduce engineering design and analysis.
- Introduce laboratory data acquisition and analysis techniques.
- Develop the teamwork approach to the solution of engineering design projects.
- Develop report preparation and presentation skills.
- Heighten student interest in engineering as a profession

These one semester-hour courses meet once each week for a three-hour period. Typically. the first hour is used for lecture and discussion while the last two hours are used by the students to work on computer assignments and/or their team design project. A textbook was compiled using three modules from the Benjamin/Cummings Engineers Toolkit, [5,6,7]. Lecture notes supplement the textbook.

Computer Skills

The introduction to the personal computer was divided into five segments during the first semester course. The first two laboratory periods were used to introduce the students to DOS and the Windows operating system followed by three laboratory periods to introduce the basics of word processing. Two laboratory periods were used to introduce the concepts of spreadsheet analysis followed by four laboratory periods where Mathcad was introduced. The final segment on the personal computer covered the basics of e-mail, the World-Wide-Web, and computer-based library resources.

The sessions on DOS and Windows emphasized file, directory and disk structure, file management tools and program execution tools. The students spent most of their time in these labs exploring the directories and programs within the Windows operating system. The students were required to create directories and subdirectories on both the hard drive and their personal diskettes and to demonstrate their ability to move and copy files between them. A typical laboratory assignment was to write a brief memo using the Write software and import something they drew with the Paintbrush software into their memo. The memo was then to be saved to a laboratory subdirectory on their personal diskette and turned in at the end of the period. Throughout the course, the students submitted all of their computer assignments on both diskette and paper.

During the word processing portion of the course the students were introduced to the general processes for formatting text and writing memos, letters and reports. The students learned to format tabular data and to import ASCII files into data tables. A short time was spent introducing the student to the equation and picture editing fictions. Typical laboratory assignments were to complete exercises from the textbook module in which they would write letters and memos which included tables and/or equations.

Two laboratory sessions were spent on spreadsheet analysis. The basic concepts were introduced with emphasis on the use of built-in functions and sorting algorithms. The students then investigated the multitude of graphing tools which are available in the software.

Four laboratory sessions were spent introducing the students to the Mathcad software. The first session was spent on the fundamentals of Mathcad and explanations of the basic equation and text operations. The group of tired and unenthusiastic students became highly motivated when the professor worked their calculus homework problems in about three minutes using the symbolic processor (the screen was then quickly cleared). The second and third sessions were spent on function development, solutions to systems of equations, vector and matrix notation, and graphing and plotting of results. The final session covered the basics of statistical operations, histograms and surface and contour plots. During each of these laboratories the students completed exercises from the Mathcad textbook module.

One laboratory session was spent introducing the students to the basics of e-mail, the Internet, and computerized library resources. The students spent time “surfing the net” for information on their design project and a presentation was made to the students by library personnel on computerized library databases

Engineering Analysis and Design Skills

' The students were introduced to a systematic methodology for both engineering analysis and engineering design problems. These methods were discussed throughout the semester with an emphasis on verifying and testing results, i.e. the importance of reality checks. The students were required to perform these "reality checks" on all of the analysis problems which they solved using the spreadsheet and Mathcad software.

A group design project was assigned during the fifth week of the semester. Design groups of four students were assigned by the instructor for the eleven-week project. Each group was given two standard mouse traps and told that their task was to design, build, and demonstrate a device to accurately throw both a golf ball and a Ping-Pong ball at a fixed target. A scoring algorithm was provided which encouraged the students to maximize distance while minimizing both error and the cost of their launcher. The students were not allowed to use any additional source of energy and the total cost of their project could not exceed twenty dollars.

Near the end of the semester a day was designated for demonstration of the launchers from each of sixteen groups. In addition to the final competition, each group was required to give a progress report to the instructor each week, keep an engineering log book, give a final oral presentation and submit a formal final report. The computer skills taught during the semester were used in creating the final project reports. Since this was a first semester freshman course the students were not expected to perform extensive analyses; however, brief reviews of physics and dynamics, including pertinent equations, were given as an optional evening seminar.

The teams showed a great deal of originality and creativity during this project. The final designs included a spoon attached to the two traps, complex mechanisms swinging club heads, and a mouse trap powered compound bow. Golf ball and Ping-Pong ball distances were as high as eighteen and fifty feet, respectively; several teams with shorter distances reduced their targeting error to nearly zero. The final launcher cost for most teams was less than three dollars.

In addition to learning teamwork and the engineering design method many students learned valuable lessons associated with the problems encountered in taking an idea from paper to production, Many of the students had no previous experience working with hand tools and general shop equipment and many of the groups spent hours puzzling over the problem of non-repeatable launcher performance.

There were two additional, and unexpected, benefits from this freshman design project. First, a camaraderie developed within this group of students. It started within the individual teams and spread through the entire group. These students now feel that they belong here and they are interacting with the faculty and other students in ways that are not normally seen until the junior or senior year. Secondly, the project seems to have sparked some interest in engineering science. Questions starting with "when are we going to learn about . .." are becoming common.

Data Acquisition and Analysis Skills

During the second semester course the student is introduced to physical measurements and control of physical processes using the digital computer. In these laboratory exercises, the student connects the computer to physical equipment and, through computer operations, becomes acquainted with some signal and system concepts.

A minimum of two laboratory periods are allocated for each experiment. The students are required to prepare a written report on each experiment and make several oral presentations during the semester,

The purpose of the first laboratory exercise is to introduce the student to concepts of dynamic systems. This exercise involves collecting and plotting test data and extracting constants for a given form of model equation. Using a digital-to-analog (D/A) converter, the computer is used to apply a step voltage to a motor shaft position controller. Shaft position data is collected by the computer using an analog-to digit a I (A/D) converter. These data are used to determine the constants in the model equation:

$$c(t) = k\left\{1 - e^{-\frac{t}{\tau}}\right\} \qquad 0 < t < t_{max}$$

where k and τ are to be estimated; t represents time and c(t) represents the shaft position. The model deduced from the test data is simulated on the computer and the response of the simulation is compared with the actual response of the physical system.

A second laboratory exercise involves measuring and controlling fluid flow in a hydraulic test loop. A computer output controls the pump shaft speed which determines the system flow rate. The student collects data which is used to plot a correlation curve relating system flow rate to the computer output. This correlation curve is then used to determine keyboard entries for predetermined flow rates.

An additional laboratory exercise involves measuring and controlling the fluid level in a tank. The students use the computer to monitor the fluid level and to provide the necessary control signals. If time permits, additional exercises are completed by closing a feedback loop through the computer.

A fourth laboratory exercise involves measuring and controlling the speed of an integral horsepower electric motor with the computer. A standard 4 to 20 mA signal from the computer determines motor speed through a power electronic controller. A tachometer senses the speed of the motor shaft and this speed signal is returned to the computer. The students collect this data and generate a calibration curve of motor speed versus control signal. If time permits, feedback control through the computer is implemented and the advantages of closed-loop over open-loop operation is demonstrated.

Important fundamental signal and system concepts are introduced in several laboratory exercises. The concept of frequency response of a linear system is demonstrated; students use existing software to perform a frequency response test of an R/C circuit. The concept that a nonlinear system causes a sinusoidal signal to be transformed into a nonsinusoidal, but periodic, output signal is demonstrated. The students perform a fast Fourier transform analysis on the output data from a nonlinear device. Using the transform data the student attempts to synthesize the previously obtained output waveform. Time permitting, other concepts are demonstrated.

Summary

The two one-semester-hour courses acquaint the students with the power of the computer as an engineering tool and motivate them to develop their computer skills. As these skills developed students freely used them in other engineering courses. This allows more latitude in the types of problems which can be assigned. The students are familiar with the computer as a data acquisition and analysis tool. Communication skills are improved through written and oral present ations. Team skills are developed through group projects and presentations. Perhaps the most exciting product of the two courses is the increased enthusiasm interest, and commitment shown by the students (and professors).

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