Session 2553

A Multi-faceted First Year Electrical and Computer Engineering Course

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I. Introduction

An innovative course at the University of Cincinnati combines introductory level technical materials with the development of academic survival skills and a hands-on laboratory experience to produce an Introduction to Electrical and Computer (ECE) course for incoming freshmen. The course, which is offered to ECE freshmen in their first term, is designed to promote retention of engineering freshmen via several avenues. First, the course allows students to become acquainted with their major early in the curriculum. Beyond introducing the sub-disciplines of ECE, students engage in a variety of activities that are designed to introduce them to the people and resources that will help them succeed, including: professors in their major, academic advisors, deans, engineering librarians, national/international co-operative education advisors, ECE upperclassmen, and leaders in the engineering student organizations. Second, the course promotes freshmen retention by highlighting the skills and technologies that ECE students learn after completion of math and science core courses. Finally, experiments in the lab portion of the course promote freshmen retention by showing students that engineering is fun!

While the primary objective behind this course is the improvement of freshmen retention, an introductory course must also prepare students for the engineering courses that follow. Thus, while the course content has been selected to highlight the broad spectrum of ECE topics, course activities are also selected to allow the development of design, analysis, communication, and teamwork skills. Ultimately, the course prepares students for continuation of their studies while helping them to form bonds with their classmates that will eventually lead to small study groups that are vital to academic success.

This paper describes the structure and content of the lecture and laboratory portions of the course and describes the relationship between this course and ABET Engineering Criteria 2000 outcomes. Finally, the paper presents preliminary course assessment results.

II. Lecture Topics/Activities

Students meet twice a week for two one-hour lecture sessions with a maximum section size of 24 students. About 5 weeks of the lecture portion of the course are devoted to technical, discipline-specific material, and the other 5 weeks are devoted to academic orientation activities. The technical portion covers the basics of computer organization starting with transistors and progressing to digital logic gates, functional units, and an instruction set architecture. We use the first 4 chapters of Patt and Patel's introductory textbook[1] that are created in a custom print run for us by the publisher. The softcover book with only the necessary chapters retails for less than half of the cost of the entire hardcover book. Students have at least 5 homework assignments and 2 tests over this material. Most of the assignments are exercises from the textbook used to reinforce concepts, but one creative digital design assignment is given. The students create a truth table and simple gate diagram to implement functional specifications. This assignment gives them a foretaste of future design classes. The computer organization background prepares the students for the next ECECS course they take, Computer Science I (introduction to programming in C++). We follow the same bottom-up approach taken by Patt and Patel to understanding the basic underpinnings of computers prior to studying high-level programming concepts.

Many of the academic orientation-type lectures are part of a single goal-directed activity: the final assignment of the term is for each student to write his or her dream resume[2] that reflects the student's college accomplishments and experiences. The dream resume embodies positive visualization that sparks both investigation and planning on the part of the student, as well as requiring exploration of various resources to justify items on their resumes. The resume includes the following items:

1. G.P.A. and class ranking (out of 50 students),
2. name of college, major, minor(s), and date of graduation (e.g., University of Cincinnati College of Engineering, EE or CompE major, VLSI/Photonics/Math/etc. minor, June 2005),
3. all honors and awards earned,
4. co-op experience (where, how many quarters, responsibilities),
5. technology skills mastered, and
6. campus organizations/activities.

In addition to the one page resume, one page of justification that includes the following is submitted: at least one library reference (an article) on a technical topic used in the resume, one webpage reference for a technical topic, one use of a Career Development office resource, one interview of an EE or CompE upperclassman, one interview with a member of a campus engineering organization, and one interview of an ECECS faculty member. Some of these are facilitated by in-class activities such as a guest lecture by an Engineering Librarian that includes demonstration of electronic resources, a lecture by the ECE co-op advisors and the international engineering advisors, guest lectures from ECE professors, and small group discussions with upperclassmen and leaders of engineering organizations. Representatives from Engineering Tribunal (an engineering college service organization), Tau Beta Pi (engineering honorary society), Eta Kappa Nu (ECE honorary society), two engineering fraternities (one of which is co-ed), Bearcast (internet radio broadcast club), the National Society of Black Engineers, the Society of Women Engineers, and the Institute of Electronics and Electrical Engineers participated in the discussions.

The lecture portion of the class devotes a week to discussion of engineering ethics, with particular focus on workplace ethics (since all of our students co-op) and ECE case studies. We use Schinzinger's discussion of an engineer's sphere of influence[3] to provide context for the discussion. Engineers make decisions that may impact various groups, and in turn they are influenced by different groups of people. The groups include co-workers, family, society in general, government, and professional societies. To introduce students to the ethical guidelines of a professional society, we discuss the IEEE Code of Ethics. We consider case studies from the Ethics Challenge game[4] selected by seniors in the class of 1999 as being relevant to their co-op experiences. Students work in small teams to select a multiple choice answer for each case study, then we discuss the alternatives as a group. As a more open-ended and discipline-specific exercise, we examine recent ECE cases[5]. Each student writes an essay discussing which groups of people are most affected and how, as well as which IEEE tenet most closely applies and why.

The remainder of the academic orientation-type lectures discuss engineering in general, ECE careers and predictions for growth, EE and CompE curricula, and selection of humanities and social sciences courses to meet college requirements.

III. Laboratory Activities

Several universities offer laboratories in first year experience courses, however a national survey of first year seminars[6] reported 755 institutions with first year experience programs, and only 20 of those reported professional or discipline-linked seminars or courses. None of these reported hands-on laboratory experience, so this is still relatively rare.

The lab portion of the course meets once a week for at least two hours, and has been designed with two key objectives in mind. First, since most students enter the program without a clear understanding of how the two disciplines compare, the lab introduces students to the fundamental concepts that distinguish the areas of Electrical and Computer Engineering. Second, in order to pique the students' curiosity, the labs are designed to be interesting and fun. Since the students in our programs do not take any ECE courses until their sophomore year, this is an important objective. Unfortunately, the math and science classes required during the freshman year discourage many students. By meeting these two primary objectives, the lab part of the course engages a student's interest in the field while justifying the need for basic math and science courses taken in the freshmen year.

The labs are divided into two sequences of four labs each. The first sequence of labs focuses on

EE topics. The second sequence of labs uses RoboLab robotics kits (an educational product from Lego Dacta). RoboLab allows students to build robots by interconnecting Lego pieces. One specialized Lego brick is a micro-controller that is programmable via a graphical programming environment installed on a PC. Ease of use was a factor in our selection of RoboLab since it is not expected that incoming students have prior programming background, yet the visual constructs they learn provide intuition for the text-based programming language (C++) they learn in their next quarter. The sequence of labs developed around the RoboLab equipment focuses on CompE topics. The labs in both sequences are described below.

Electrical Engineering Sequence

1. Crystal Radio Lab: introduces the students to the interesting concept of an AM radio with no internal power source. The students learn the fundamentals of AM signal detection with a simple RLC detector. The lab also serves to introduce them to the basic components of electrical circuits, and gives them the opportunity to build their own circuits by soldering components together.
2. Digital Signal Processing (DSP) and Communications Lab: serves to educate the students on the everyday uses for signal processing. The lab consists of an interactive software program, written in Matlab, which implements a wireless modem using a speaker and microphone connected to a PC. As most of the students are familiar with the use of modems with their own computers, the lab serves to familiarize the students with basic ideas in signal processing by illustrating how their own modems work.
3. Introduction to Photonics Lab: provides three experiments to highlight different applications of photonics. The students measure the physical properties of optical fiber, examine the use of light in an optical sensor system, and perform image processing using spatial filtering.
4. Experiments with Digital Systems Lab: provides a way for the students to learn the basics of Boolean algebra, and implement several logic functions using chips consisting of NOR, NAND, and XOR gates. The timing of this lab is coordinated with the lecture portion of the course so students have the opportunity to reinforce the lecture content with hands-on experience building logic circuits in the lab

Computer Engineering Sequence

1. Introduction to RoboLab: introduces students to the graphical programming environment that is used with RoboLab. In addition to learning the basics of writing programs, students learn to control robot motors and read data from touch sensors and light sensors.
2. Robot Construction and Programming Lab: has students build a pre-planned robot and then program it to move and sense things in its environment. In addition to learning how robots can be built with Legos, the lab extends the programming skills learned in the previous lab by showing how robot motion and sensor-actuated control can be incorporated into a robot program.

3. Line-Tracking Robot Lab: requires students to write a program that allows a pre-built robot (with optical sensors) to follow a black line that traces out a circuitous route on a white surface. In this lab small groups of students compete to produce the fastest time through the path.
4. Final Design Project: requires student teams to design, build and program a robot to locate a ball (held on a ball stand), transport the ball to a basket, and place the ball in the basket. The robot must work on a platform containing one basket and two ball stands. The platform is designed such that two robots can compete head-to-head and thus allows a class competition to determine the best overall design.

In addition to participating in the lab project each week, the students are required to keep a laboratory notebook that describes the lab work and answers questions regarding the content of each lab. Each week students submit carbon copies from their lab notebooks for grading. At the end of each lab sequence, every student must submit a formal lab report focusing on the last lab of the sequence. These reports give each student experience in producing formal descriptions of the procedures they follow and the results they obtain in the lab.

IV. Relationship to ABET EC 2000 Criterion 3

ABET EC 2000 Criterion 3 lists 11 outcomes that are expected of all graduates of accredited engineering degree programs:

a. an ability to apply knowledge of mathematics and engineering skills.
b. an ability to design and conduct experiments, as well as to analyze and interpret data.
c. an ability to design a system, component or process to meet desired needs.
d. an ability to function well on multi-disciplinary teams.
e. an ability to identify, formulate, and solve engineering problems.
f. an understanding of professional and ethical responsibility.
g. an ability to communicate effectively.
h. the broad education necessary to understand the impact of engineering solutions in a global and societal context.
i. a recognition of the need for, and an ability to engage in lifelong learning.
j. a knowledge of contemporary issues.
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The table below indicates aspects of the course that contribute toward each outcome.

Outcome	*Lecture Activity*	*Lab Activity*
a		calculations based on gathered data are required in the Photonics and DSP labs
b		many of the labs require data collection and analysis, and some labs require interpretation with subsequent adjustment of experimental setup
c	digital design homework	final design project and the Line Tracking Robot
d	some homework done in pairs; in-class discussions done in small teams	EE/CompE students mixed on teams of 2-3 students for all labs
e	solving computer organization problems in homework	final design project and the Line Tracking Robot
f	ethics case studies and codes	
g	written assignments; dream resume requires both writing and oral communication in interviews	two formal reports written based on results gathered during execution of lab projects
h	discussion of community service with engineering organization members; societal context for ethics cases studies	
i	discussion of changing pace in their chosen professions, graduate school	
j	ethics case studies include recent ECE topics	
k	study and apply techniques in computer organization and processing; electronic library and internet resources	learning to use the graphical programming environment associated with the RoboLab

We believe our Introduction to Electrical and Computer Engineering course acquaints students in some degree with all of the ABET Criterion 3 outcomes we expect them to have upon completion of their degrees.

V. Preliminary Assessment

It is too early to give any longitudinal results regarding retention, but we are able to report feedback on student satisfaction with the course. Regarding the lab portion of the course, students were asked to give a numeric score between 1 and 10 (with 10 being the most positive) for 1) how informative the labs are, 2) how enjoyable, and 3) how effective they are in providing basic skills in fundamental ECE areas. In Fall 2000, 83 students responded in the midterm survey and 102 responded to the final survey over all of the labs. The average scores for each are given in the table below. A two sample test showed a statistically significant increase in all areas for the second survey. One possible explanation is that students preferred the robotics laboratories in the second half, or that they simply became more comfortable with the activities and expectations in the labs as the quarter went on. Students appear to enjoy the labs and find them both informative and effective as a hands-on experience in their majors.

question	*midterm average*	*final average*
1) informative	7.77	8.55
2) enjoyable	7.64	8.95
3) effective	8.12	8.72

Regarding the lecture portion of the course, students were asked about the coverage for each topic (whether it should be increased, stay the same, or be decreased.) A score of 5 represents the same coverage, and 0-4 represent decrease, 6-10 represent increase. The topics are shown below in order from the highest score for increasing coverage to the lowest score for decreasing coverage. A t-test shows that several of the means were significantly different from 5, indicating a student consensus that the time devoted to the topic should change. These are denoted by * in the table. Interestingly, no topics had significant scores for decreasing coverage, but there were several for increasing coverage.

topic	*score*
* ECE fields and careers	6.51
* visit from upperclassmen and organization representatives	6.25
* von Neumann architecture	6.03
* discussion of engineering in general	5.94
* visit from co-op advisors	5.93
* EE/CompE curricula	5.87
* digital logic structures	5.66
* bits, bytes, and encoding information	5.42
visit from international co-op advisors/students	5.42
engineering ethics	5.21
overview of computer system organization	5.08
visit from engineering librarian; electronic resources	4.59

A possible revision for the next offering of the course would be to schedule an additional visit with ECE upperclassmen earlier in the quarter to discuss co-op and career opportunities.

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