The Best of All Worlds - A First-Year Course at the University of Maine

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Abstract
ECE 101 *Introduction to Electrical and Computer Engineering*, a first-year course for electrical and computer engineers at the University of Maine, is described. It uses a variety of approaches to introduce students to their major and to help make them successful students.

I. Introduction

Many engineering programs have an introductory course in the first year. These introductory courses use a wide range of approaches to teaching and learning and cover a broad range of topics. Some emphasize the skills necessary to be a successful student, skills like, learning styles, study skills team building, and types of engineering jobs. They might use texts similar to Landis[1] or Donaldson[2]. Some of these also introduce design, using projects like egg drops, bridge building, or discipline related endeavors. Other introductory engineering courses emphasize a more technical approach, using, for example, a text like White and Doering[3]. Some of the more technical courses are discipline-based[4] while others serve as an introduction to the major engineering disciplines[5]. ECE 101 combines the general skills development philosophy with an ECE discipline-based approach.

Techniques used to enhance learning in first-year courses include, technology usage, peer teaching, collaborative learning, hands-on activities, a minimum of lectures, and small classes.

In an effort to provide a good start for our students we have borrowed from the wide range of available teaching techniques and topics to create ECE 101 *Introduction to Electrical and Computer Engineering*, hence the semi-humorous portion of this paper's title referring to "The Best of All Worlds". Beginning with a brief history, details of the course are presented next.

II. History

For over twelve years the ECE Department has required two courses in the first year curriculum to introduce its majors to their discipline. Initially, both of these courses were wholly technical where one course dealt with digital logic and the other with assembly language programming. In the early 1990's the digital logic and assembly language material were combined and taught in the second course. This allowed the first course to be restructured to provide a general introduction to electrical and computer engineering, including modules aimed at helping students

make the transition from high school to college. However, this new course had problems, including being too fragmented (the modules lacked a clear thread), the classes were large, and there were no hands-on or design activities other than simulations using computers. In order to address these issues, as well as to introduce some of the "best practices" of others, a series of revisions was begun. The changes in the last few years have been incremental so that we have a reasonably stable course and one that fits our situation well. After a brief overview, the current status of the course is described.

III. Overview

ECE 101 was developed to help ECE students get a sense of community within their Department, introduce topics that are covered in more detail in upper-level courses, give a first look at design, and generally help them be successful engineering students. It emphasizes a personal touch, which means the ECE Department devotes considerable resources to staffing. Two faculty members (1-FTE) are assigned to the course, which normally has about 60-70 students. Also, three to four undergraduate students are employed as peer teachers and to help in lab. The class meets Monday, Wednesday, and Friday mornings for 50 minutes. Additionally, there is a weekly 3-hour lab (four sections are offered with 15-20 students in each).

As an aid to learning student names we take "mug shots" during the first laboratory period with a digital camera. The students print their names (using a nickname if preferred) on an 8.5" x 11" sheet of paper that they hold up in front of them for the picture. A typical mug shot is shown in Figure 1 (a pseudonym was substituted for the real name). A picture is printed out for the student's Department file and then all pictures are consolidated 9 to a page to make "mug sheets" that are a tremendous help in associating student names and faces.

Figure 1. A typical "mug shot" created for Department files and to help learn student names.

To help maintain communications and to make information available electronically, we use a computer conferencing system called FirstClass. In addition to providing a general email service it allows the creation of a "conference" for an individual course. A conference is essentially a bulletin board, e.g., allowing ECE 101 students and faculty to post comments, questions, and answers for all to share. It also allows documents to be attached to messages so that they can be downloaded by all. We make particular use of this latter feature in a module on Mathcad.

A unique approach is used to create a small class environment. On Mondays and Wednesdays half the students go to one classroom for a general engineering discussion while the other half go to another classroom to learn about an ECE topic. Halfway through the period, the classes switch. We lose about 5 minutes in the switch but we gain a class that has had a "7th inning stretch" and one that is ready for a change in topic.

As mentioned in the Introduction, the course has two primary divisions, a general engineering part and an electrical and computer engineering discipline-oriented part. The general engineering segment is described next, followed by the Electrical and Computer Engineering portion.

IV General Engineering Segment

This portion of the course is taught by peer teachers. In the Fall 2000 semester, a junior and a sophomore were the leaders. We have found that carefully selected peer TAs make connections with the students that regular faculty cannot. Typical topics include: study and test-taking skills, oral presentations, working in groups, using the library, faculty research projects, various types of engineering employment, and ethical situations faced by engineers. Some of the general engineering module activities are described next.

Twice during the early part of the semester we deviate from our split period approach and have full 50-minute periods on Monday and Wednesday. First, on Monday of the second week of classes, half the students meet for breakfast in the cafeteria while the other half have a lecture, then on Wednesday they switch. This informal gathering gives the students an opportunity to get to know each other and, with some guidance from the TAs, to talk about roommates, classes, or anything with which a peer might be helpful.

The second time we separate for a full period is for a session on library usage. This happens about the middle of the semester and is a prelude to a library research project. The students, in groups of two, research a current technical event in preparation for an oral report that includes a timeline, what kinds of engineers were involved, and the relevance to the public. As part of the oral report they develop visual aids. Topics from this fall included, Napster, the Concorde crash, development of LEDs, Mars surveyor, and jet noise reduction.

Other oral reports deal with an "invention" that they would like to create. These do not have to be realistic, but if they are on the fanciful side it is expected that they will be humorous. They do not disappoint! Two examples of student inventions from Fall 2000 include "Grandma in a Can" and "A First Year Student's Everything You Need Hat". The former is a can that you can open anytime you are feeling down and your grandmother will help you feel better. The latter is a cap with useful items attached to it and is presented in Figure 2. Attached items included a tea bag, ruler, pencil, cocoa, and a large safety pin.

Figure 2. A First Year Student's Everything You Need Hat

The general engineering segment has a design component. The students, again working in groups, are given cups, straws, and toothpicks and asked to design a holder that will protect an egg when dropped from about 10 feet onto a cement floor. There are costs associated with each part they use, e.g., a cup might "cost" $50, so the winner is the team that has the lowest cost while still protecting the egg.

As part of the process of introducing them to the profession we have tours of labs and presentations by faculty where they discuss their research as well as the courses in their specialty.

It took a little while to find the right mix of material for the general engineering portion. For example, too much of the "here's what you need to be successful" material and the students felt talked down to. However, we feel we have a good mix now as illustrated by student evaluations for the Fall 2000 semester that were very positive. Some representative comments follow.

Comments from Fall 2000 evaluations of the general engineering segment of ECE 101

- "I liked the laid back atmosphere."

- "I think this class had a positive effect on my education. Reviewing study habits and test strategies came in handy more than once. Most of all it allowed me to get to know the people I might be graduating with one day."
- "This class was helpful. It cleared up some of my questions about classes, registering and the library."

V. Electrical and Computer Engineering Segment

As mentioned in the History section, we initially had problems with this segment because it was too disjointed. However, we now use the construction of a remote controlled vehicle to provide a connection between topics and to provide motivation for their study. They are given the mechanical part of the vehicle and are expected to construct the electronic controls. Students work in teams to accomplish this goal. This approach is similar to that used in the University of Illinois' ECE 110 course[6]. The topics lead naturally one to the next in the following order: resistive circuits, RC circuits, 555 timer, combinational logic, Karnaugh maps, sequential logic, DC motors and PWM control, and how these all fit together to make the vehicle work. They also learn the hands-on skills of soldering, wire wrapping, how to read schematics, use basic lab equipment, and trouble shooting. Finally, they gain an appreciation for the importance of a modular approach to design and test. The vehicle construction culminates in a head-to-head competition (different each year) that requires students to modify the vehicle to perform some function.

The contest for the Fall 2000 semester is summarized in the following:

Excerpt from ECE 101 Contest Description Fall 2000

Introduction

The challenge for Fall 2000 is to modify your car so that you can get tennis balls to your side of the "playing field" described below. Your car may be modified in any way you like to improve your chances as long as the modifications are not in conflict with the rules.

The Setting

The contest will take place on a 4-ft by 8-ft plywood surface, the "playing field", with boundaries to prevent cars from leaving the surface. At each corner of the table will be a triangular hole large enough for a tennis ball to pass through but with a small barrier to prevent balls from rolling into the hole. The table will be level and at approximately desk height (~ 30 in) during play. The table will be divided in half through the 8-ft. dimension and each team will "own" half the table and two of the holes. At the start of the contest, each team's car will be placed so that the center of its back end (the end with the motors) touches the center of the 4-ft barrier on its end of the table. Three tennis balls will be used in the contest and at the start of each contest they will be inserted in a thin piece of fiberboard approximately 7" off the middle of the table (there may be some sag). The balls are accessible from the top and bottom of the fiberboard. Each contest will have an

official timer who will start the contest and then stop it after 2 minutes.

The Object

The object is to get as many tennis balls as you can to your side of the playing field. If a ball goes through a hole on your end of the table you get 10 points. If a ball is within 1 foot of the end you get 5 points. If a ball is within 1-3 feet of your end you get 3 points. The winner of the contest will be the team that has had the most points at the end of the two minutes. The placement of the balls will be evaluated at the end of the 2 minutes. If a ball goes over the edge it is out of play and does not count. The balls do not have to rest on the playing surface in order to be counted. For example, if a ball is on or above the region 1 foot from the table end that team will receive 5 points.

Figure 3 shows the playing field at the start of the contest and Figure 4 shows one of the more successful designs as the vehicle unloads tennis balls directly into one of the corner holes.

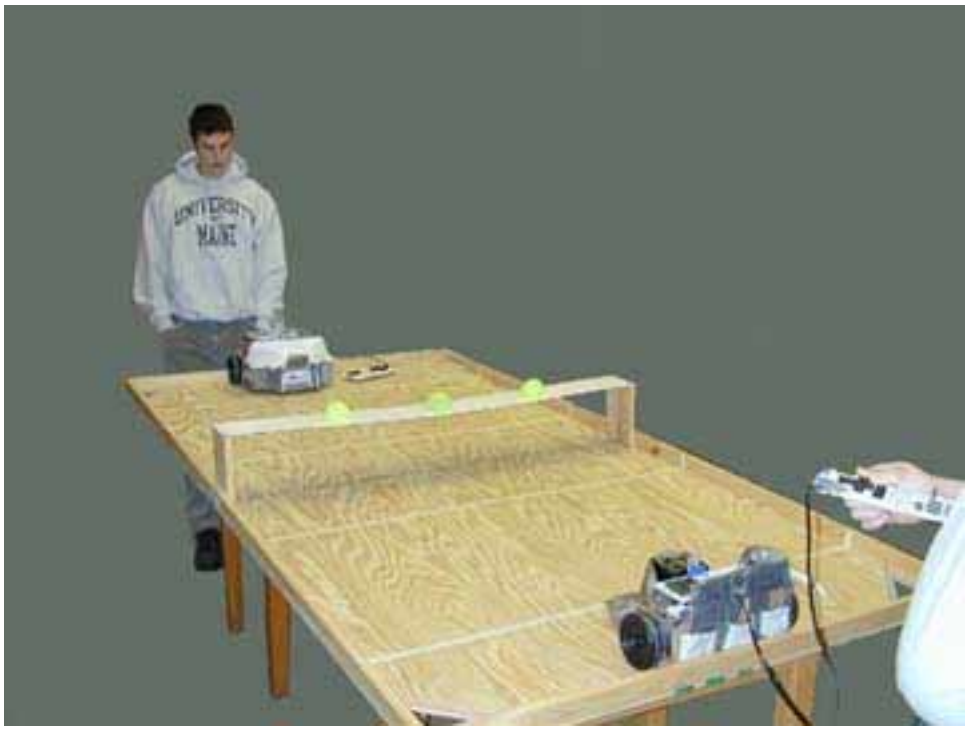

Figure 3. The contest "playing field" at the start of a contest. Note the corner holes and the scoring regions.

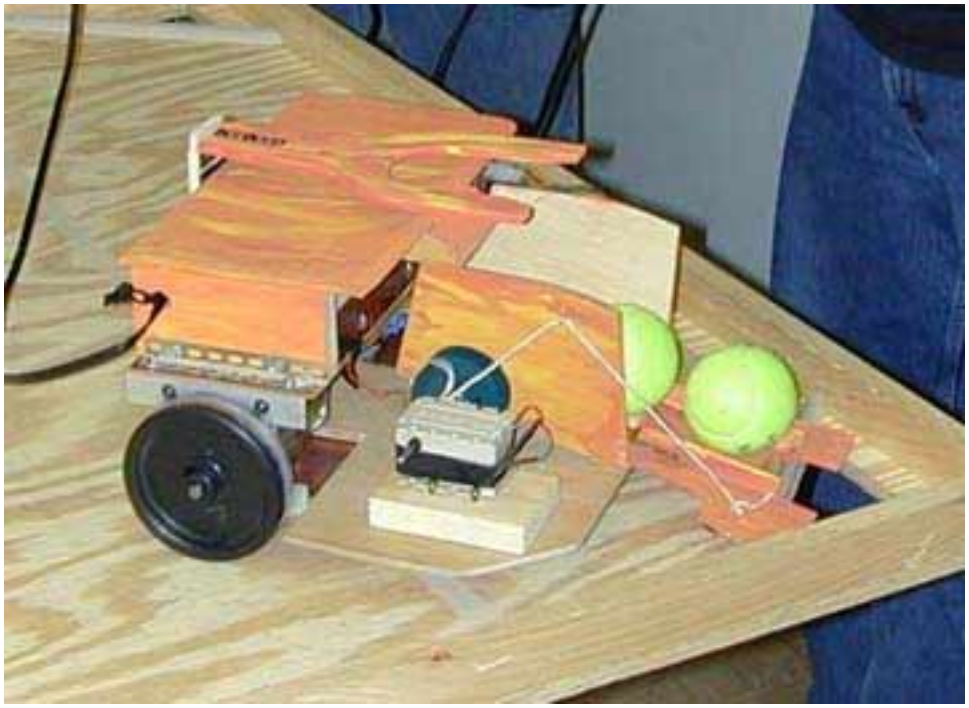

Figure 4. Unloading balls that were pushed into the carrier using the U-shaped arm

To present the ECE topics we use very little straight lecturing. We agree with Felder[7] that lectures do not work as well as we may have once hoped or expected. So, instead of long lectures, we briefly present a concept, then break the students into two to four person groups, and use in-class collaborative learning activities to check on understanding. This has proved to be an excellent way to maintain interest and to let the students know where they need to put in some work if they don't feel comfortable with the material. As an additional aid, we developed some web-based exercises to help students asynchronously test their understanding. The exercises cover resistive circuits, RC circuits, 555 timers, and combinational logic circuits. Student evaluations of these exercises during the Fall 2000 semester ranked them 4.4 out of 5 where 1 was "Not at All Helpful" and 5 was "Very Helpful".

Another topic covered in the ECE segment is an introduction to Mathcad. Here again, splitting the class is an advantage because we can make use of a PC cluster to handle half the students at a time. We do very little lecturing here, too. Instead we have students download a Mathcad document that has a discussion of the topic to be covered. It also has an activity for the students to perform to test their understanding. We call these modules Tutorials. When completed, the Tutorial is printed out, it is signed by an instructor, and it is placed in the Student's notebook for reference. The additional tutorial material is particularly necessary because the only other written support material is the MathSoft User's Guide[8] which is more of a reference than a text. Mathcad topics covered in this segment include; Text and Math regions, graphs, solve blocks, range variables, vectors, importing and exporting data, Boolean operators, and programming. Many of our students have no experience in programming so the basic programming capability

available in Mathcad's Professional Version has been a great way to introduce basic programming constructs like if statements, while-loops, and for-loops. Fall 2000 was the first time programming was introduced so we are anxious to see if it helps in subsequent C++ and assembly language courses.

VI. Conclusion

ECE 101 has evolved into an excellent bridging course between high school and college. It uses a variety of approaches to provide an introduction to electrical and computer engineering and to help students be successful. Based on student evaluations and retention trends it appears to be succeeding in its goals.

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