Web-Enhanced Instruction and Assessment for a First Laboratory Course in Electrical and Computer Engineering

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Abstract

Electrical and Computer Engineering students taking their first core laboratory course respond well to web-based instruction recently implemented at Auburn University. Pre-lab introductory reading and exercises, and in-lab experimental procedures are provided to the students on the course web site. These in-house materials are supplemented by links to publicly available JAVA-based demos, manufacturer's data sheets, and various sites focusing on interest areas such as electronic music, biomedical research, and robotics. Students readily accommodate to this delivery method, and students and instructors alike find it preferable to a pre-printed laboratory manual because of the wealth of support information that can be included, and the ease of including annotated color photographs of equipment and components.

I. Introduction

Auburn University switched from the quarter system to the semester system in Fall 2000. As part of the transition, the required core laboratory courses in Electrical and Computer Engineering were entirely redesigned. The new laboratory sequence includes one required core laboratory course each semester of the sophomore and junior years. The laboratory courses are not directly linked to specific lecture classes, but the experiments are carefully designed to synchronize to a great degree with the standard curriculum. The focus of this paper is the first sophomore laboratory course (hereinafter referred to as Lab I), which provides an introduction to safety, instrumentation, analog circuits and devices, and digital circuits and components.

In Lab I, it is often the case that students require some background, which they have not studied in any lecture, to understand and conduct a given experiment. For example, Lab I includes an experiment using operational amplifiers, although op-amps are not formally introduced in lecture until the second electronics course. The latter course is normally taken in the first semester of the junior year. The challenge, therefore, is to design experiments that are interesting and stimulating, while providing the necessary background, often without assuming students have exposure to the topic in lecture. Use of web-based instructional tools provides a way to accomplish this, while simultaneously providing exceptional flexibility to the instructor to modify and update course materials in response to assessment feedback.

Web-enhanced engineering laboratory instruction has been reported in the literature recently[1–3], and is in place at a number of U.S. universities, including the University of Nebraska at

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Lincoln[4], Northeastern University[5], University of Florida[6], and the Colorado School of Mines[7], to name a few. The web-based content associated with these laboratory courses ranges from syllabus supplements to full experimental details, including equipment descriptions and pre-lab quizzes. In each case, however, there is reference to a printed laboratory manual which accompanies the web-based material. In the implementation at Auburn, we do not have a printed laboratory manual- all of the primary instructional material is online and accessed through the course web site.

II. Development of the Web-Based Instructional Materials

The original course materials for Lab I were drawn primarily from an existing set of experiments designed over the past several years for a sequence of three, quarter-long, interdisciplinary sophomore laboratory courses, with additional inspiration from the junior year laboratories[8–10].

Materials are continuously refined based on experience. Feedback on each experiment is acquired from students and instructors each week, and this is used to gauge and adjust such factors as the length of the experiment, effectiveness of the prelab material, and the level of challenge provided by the experiment.

Material for each experiment is separated into prelab and in-lab documents, and then posted on the course web site in either Microsoft Word or Portable Document Format (PDF). The latter format seems to be the most universally readable by students. In the first semester of implementation, approximately seventy students using a variety of platforms and access modes (dial-up, broadband, campus Ethernet) have been served with no complaints about accessibility using PDF. File sizes for prelab and in-lab documents are kept below 100 kilobytes so as not to disadvantage students with dial-up access. This is found to be a reasonable cap even for files containing several color photographs of instrument panels.

III. Preparation of Instructional Documents for Web-Based Delivery

Lab documents are prepared using Microsoft Word. Consideration was given to using LATEX (an industry standard typesetting tool), but it was determined that document maintenance would be simplified by using a more commonly employed word processor with which most students and clerical personnel were already familiar.

Some documents include photographs of instrument panels and components. These are acquired with a digital camera, and imported into the word processor in JPEG format. Conversion to PDF is accomplished using Adobe Acrobat software. Photograph annotation and line drawings are typically done within Word, or with an external graphics editor such as Visio[11]. Circuit drawings are imported from PSPICE Schematics[12] or from LogicWorks[13]. One of the most challenging aspects of document preparation for the web is ascertaining that the information will be displayed correctly on any system a student might reasonably use. Various types of drawings behave differently when converted to PDF. Linewidths are not always maintained, and the on-screen view of a document is not always the same as the printed output. Microsoft Word handles positioning of graphics poorly, which means the author must pay special attention to page composition. Once converted to PDF, however, the documents are fairly stable, and the final output as viewed or printed by the student depends mainly on the student's screen and printer resolution. Care must be exercised to ensure that the essential information in photographs and drawings remains legible even at the lowest expected delivery resolution.

Final documents are posted on the course web site and listed in a link table with short descriptions. An excerpt of the main page[14] for Lab I, Fall semester 2000, is shown in Figure 1. Currently, the course home page is maintained within the instructor's home page web space. Consideration is being given to porting the course pages to a commercial product such as WebCT or Blackboard. These products offer many advantages to instructors and students, such as online, secure grade books, online assessment, etc.. However, they also impose a somewhat rigid structure on the web page design and content, and the user interfaces are not as convenient as many users would like.

IV. Supplementary Materials

Web-based instruction opens up an exciting vista of readily-accessible supplementary information. There are many useful and interesting web sites that can be linked to each experiment.

The most immediately useful links are those to manufacturer's data sheets for components, especially integrated circuits, used in the experiments. Manufacturers of electronic parts have uniformly moved to web-based delivery of parts information in PDF, so there is a seamless integration with the web-based delivery of instructional material. For each experiment, students are required, as part of the prelab assignment, to access the data sheets for the parts to be used. They bring these to the lab to use for reference while connecting circuits and performing experiments.

Other links of interest are those to sites with JAVA-based demonstrations. One example is a demonstration of the operation of a p-n junction[15]. Another example is an interactive, web-based digital logic simulator[16]. Still other links provide useful data such as TTL logic levels[17], and the standard resistor and capacitor marking codes[18].

Students are able to access these links readily, and print just the data they need to bring to lab for a given experiment.

V. Potential for Improved Assessment

Web-based instruction offers the potential for improved assessment, both for instructors assessing student performance, and for instructors and administrators assessing course outcomes. Commercial tools offer the option to give and grade quizzes online, and to provide immediate feedback to the student. Feedback from students and instructors can be used to make improvements to courseware within hours, rather than waiting for the next semester. The next phase of the work reported here is targeted at utilizing this potential.

WELCOME TO ELEC 2010
ELECTRICAL AND COMPUTER ENGINEERING LAB I
SPRING 2001
Faculty Supervisor: Dr. Thad Roppel
Syllabus
Instructor contact information, lab times and location

Instructions: *Before your lab section meets, read and study the Pre-lab document for the upcoming experiment. Work the pre-lab exercises. Some of the pre-lab exercises require internet access or computer usage. When you come to lab, bring your completed pre-lab exercises, and hardcopy of both the Pre-lab and In-lab documents. Also bring any additional information, such as data sheets or templates, as indicated in the Prelab document or in the list below.*

Exp't. #	Title	Documents Available	Dates of Experiment
1	Safety, Instrumentation, and Measurement	• Pre-Lab (Word, 1.8 M) (PDF, 132 K) • In-Lab (Word, 1.3 M) (PDF, 87 K)	Tues. 1/16 - Mon. 1/22
2	Oscilloscope and Function Generator	• Pre-Lab (PDF, 54 K) • In-Lab (PDF, 58 K) • Template for sketching oscilloscope displays (PDF, 4 K)	Tues. 1/23 - Mon. 1/29
3	Circuit Construction and Operational Amplifier Circuits	• Pre-Lab (PDF, 67 K) • In-Lab (PDF, 38 K)	Tues. 1/30 - Mon. 2/12 This is a two-week experiment, worth double credit.
4	Diodes and Transistors	• Pre-Lab (PDF, 58 K) • In-Lab (PDF, 53 K)	Tues. 2/13 – Mon. 2/19
5	Basic Digital Logic Circuits	• Pre-Lab (PDF, 43 K) • In-Lab (PDF, 46 K)	Tues. 2/20 – Mon. 2/26
6	Timing and Counting Circuits	• Pre-Lab (PDF, 56 K) • In-Lab (PDF, 38 K)	Tues. 2/27 – Mon. 3/5
7	Simulation of Logic Circuits	• Pre-Lab (PDF, 52 K) • In-Lab (PDF, 24 K)	Tues. 3/6 – Mon. 3/12
8	Medium Scale Integration (MSI) Logic Circuits	• Pre-Lab (PDF, 36 K) • In-Lab (PDF, 62 K)	Tues. 3/13 – Mon. 3/19
9	Binary Arithmetic Circuits		Tues. 3/20, Wed. 3/21, Mon. 4/2
10	Digital-to Analog Conversion (DAC)		Tues. 4/3 – Mon. 4/9
11	Two-Week Design Project (Double Credit)		Tues. 4/10 – Mon. 4/23 This is a two-week experiment, worth double credit.
	MAKEUP	Arrange with your instructor to make-up missed experiments.	Tues. 4/24 – Mon. 4/30

Figure 1. Excerpt of the main page of the course web site for ELEC 2010, the first semester sophomore laboratory in Electrical and Computer Engineering at Auburn University[14]. Empty cells will be filled with document links as the semester progresses.

VI. Summary

Web-based instruction has been developed for a first laboratory course in Electrical and Computer Engineering. Preliminary assessment results indicate that students have responded well, and have generally performed better on prelab assignments and in-lab quizzes compared with traditional delivery. Laboratory experiments are more challenging and stimulating because of the wealth of supplementary material that can be readily introduced. Experimental procedures are more understandable and more accurate due to the ability to rapidly incorporate feedback, to correct errors, and to include detailed color photographs of equipment and components.

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13. LogicWorks: *http://www.capilano.com/LogicWorks/*
14. The URL for Lab I is: *http://www.eng.auburn.edu/~troppel/courses/elec2010spring2001/index.html*
15. Java-based p-n junction demonstration: *http://www.acsu.buffalo.edu/~wie/applet/pnformation/pnformation.html*
16. Java-based digital logic simulator: *http://www0.cise.ufl.edu/~fishwick/dig/DigSim.html*
17. TTL Logic Levels: *http://www.twysted-pair.com/74lsxx.htm*
18. Resistor and Capacitor marking codes: *http://www.elexp.com/tips.htm*, *http://xtronics.com/Kits/ccode.htm*

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