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EET Laboratory Courses: From the Classroom to the Web--From Research to Practice

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Abstract

In the rush to offer courses, programs, or degrees on-line, there have been many approaches to solving the problem of including laboratory work in engineering technology programs. One approach to developing (or adapting) electronics engineering technology laboratory courses for delivery on the World Wide Web is presented in this paper. Research demonstrating the feasibility of using simulation software for the conduct of electronics lab courses on line is given as background information and used as a backdrop for the on-line laboratory pedagogy. Subsequently, the development of laboratory courses in DC circuits and AC circuits is discussed. Course content, course pedagogy, and course management are included. Successes and weaknesses from our initial attempts and information gleaned from continuing research are presented. Finally, there are suggestions for others who are developing, or contemplating, on-line EET laboratory courses.

I. Introduction

Northwestern State University of Louisiana is taking steps to increase access to education by using several technologically oriented methods in distance education. At the same time, the university has been improving its ties with area industry through partnerships. In part, these efforts have been motivated by a desire to expand the university's ability to offer courses to industry, its employees, and to other people who are not free to attend class during traditional classroom periods. While there are many examples of lecture and discussion-group classes on line, one hallmark of an electronics engineering technology program is that laboratory classes accompany most lecture courses. Though most of our lecture classes can be delivered at a distance, it is not possible to duplicate the hands-on experience of an electronics laboratory over the Internet. Even so, an on-line electronics engineering technology program must include concurrent laboratory instruction. In fact, the current criterion-based standards for accrediting engineering technology programs specify that theory courses "should be accompanied by coordinated laboratory experiences…." While Engineering Technology Criteria 2000 (ET2K) are less prescriptive, they still require laboratory course work.[1]

Through our EET industrial advisory committee and other contacts, we have begun receiving requests to offer electronics courses on-line. In the past 18 months, these requests have escalated, and now there is great interest in having an associate degree in EET available on the

Internet. As a result, we have begun offering EET courses on line. To date we have presented three lecture courses and three laboratory courses on the Internet. We are working toward getting administrative approval to offer the entire associate degree in EET on line.

This paper traces the development of introductory on-line electronics laboratory courses at Northwestern State University. It offers an approach to adapting existing hardware laboratory courses for delivery over the Internet. It includes course content, pedagogy, and course management, and it uses the DC and AC circuits lab courses and the course management and simulation software currently in use at NSU as vehicles for discussion. The information provided here could be easily adapted to other environments. It is hoped that it will help others who are contemplating similar undertakings at their own institutions of higher learning.

II. Background

Prior to offering the first on-line laboratory course, Hall[2, 3] studied the effects of using simulation software for the conduct of EET laboratory experiments. The initial effort compared groups of students who were enrolled in on-campus courses—a basic DC circuits laboratory course and an advanced device electronics laboratory course. There were no statistically significant differences in posttest scores between the groups of students who used Electronics Workbench* simulation software (from Interactive Image Technologies, Inc.) to perform lab experiments and the groups who performed the same experiments in a hardware lab environment. Similar research, but using different research designs, has continued to date. During that fall 2000 semester, the research involved two groups of students enrolled on campus in a DC circuits lab course. One group performed all labs using Electronics Workbench, and the other group performed all labs in the hardware lab. The two groups performed almost identically with the mean course grade being 71.8 for one group and 71.9 for the other. In other words, there were no statistical or practical differences between the groups caused by the laboratory treatment. **

During the fall semester of 2001, two separate sections of the DC circuits laboratory course were tested. This time, one section of the course was presented entirely on line. That section constituted the experimental group and used the student edition of Multisim (the latest upgrade of Electronics Workbench) for the conduct of all laboratory exercises. The second section, the control group, was entirely on campus. The on-campus group was allowed to use the hardware laboratory and Multisim (or Electronics Workbench) software without restriction. This was the first time we were able to compare an on-campus group with an on-line group. Previously, experimental and control groups were prohibited from conducting laboratory exercises using the equipment (or software) of the other group to ensure there was no cross-contamination of data. This time the groups were treated as though all normal resources were available. That is, the members of the on-line (off-campus) group had only simulation software at their disposal while the members of the on-campus group had both hardware laboratory equipment and simulation software. Again the two groups performed nearly identically. The groups were administered the same final examination as a posttest. The mean scores on the posttest were 82.2 and 83.2 for the on-campus and on-line groups respectively. The mean difference is neither statistically nor practically significant. ***

The previous paragraph alluded to an on-line laboratory course. At this writing, we have offered six electronics engineering technology courses via the Internet–three lecture courses and three lab courses. We piloted the freshman-level DC circuits lecture and lab courses during the fall semester of 2000 and have since developed and offered the freshman AC circuits lecture and lab courses and the freshman digital fundamentals lecture and lab courses. The DC circuits courses have been offered each semester since the pilot. The author developed the DC laboratory and the AC laboratory courses for the Web and, subsequently, mentored the developer of the digital lab course. This paper is based on experience in developing and conducting on-line laboratory courses, on feedback from students, and on quantitative and qualitative research data collected over the past four years.

III. Developing the DC and AC Circuits Laboratory Courses

A more appropriate description of putting courses on the Internet may be "adapting" courses for Internet delivery. For most of us, the courses have existed in the classroom or hardware laboratory for years, and now we wish to present them on the Internet. Nevertheless, it is important to remember that the power of the Internet is not necessarily to allow us to automate, step by step, the manual processes used in the classroom, but rather to provide a new medium to be exploited in new ways. For this reason, the courses should be adapted for the medium rather than trying to force the medium to adapt to old teaching methods.

As courses are adapted for Internet delivery, three important factors must be considered–course content, course pedagogy, and course management. While all three of these come into play in any course, only the first two command much attention in a typical on-campus class. However when delivering courses on the Internet, instructors are forced to deal with course management more directly. Often, courses are managed using software designed for the purpose. At NSU, we have made a corporate decision to use Blackboard 5 (an e-Learning software platform from Blackboard, Inc.) to manage all distance education courses, including those delivered over the Internet. Each of the three factors–content, pedagogy, and management–is discussed below in terms of developing or adapting an electronics laboratory course for the Internet.

1. EET Laboratory Course Content

In the EET program at Northwestern State University, lectures and laboratories courses are presented in separate, but co-requisite courses. Because DC circuits lecture and lab are the first electronics courses that a student encounters in the EET degree, they often serve concurrently as an introduction to electronics, to the technical laboratory, and to university-level pedagogy. In the lecture course, students learn about theoretical concepts such as voltage, current, and resistance. In the corresponding lab, they learn more practical aspects such as voltage sources, current sources, and resistors. This means that, in addition to conducting experiments to test the theory of Ohm's Law and series circuits, students must learn about the power sources, the test and measurement equipment, and the circuit components themselves. They must learn to wire and troubleshoot their circuits. (In the DC lab course at NSU, we use a short time at the beginning of the semester to teach significant digits and engineering notation while introductory electrical concepts are taught in the lecture class.)

However, the primary focus of this paper is not on the technical content of electronics laboratory courses. Whether an instructor requires one or two experiments on Ohm's Law (or none for that matter) is at the discretion of the instructor and the time available for the course. Rather, this paper focuses on the addition content required for successful delivery of the technical content. As if the technical content of a typical laboratory course were not enough, students taking their first Internet course must learn the skills necessary to navigate the course management software (Blackboard at NSU) and to use the laboratory simulation software (Multisim at NSU). NSU requires computer and Internet "literacy" as a prerequisite for taking any of its Internet classes. Most of today's college students are computer literate. However, courses are available for those needing this instruction. As DC circuits may be a student's first Internet class, he or she must spend some time learning to log into Blackboard, navigate the interface, find the necessary information, and finally respond to the course requirements. All students who register for Internet courses at NSU are required to contact the course instructor prior to the beginning of the semester. Instructors provide the students with directions on locating and logging into Blackboard. From there, announcements and course documents help students learn to navigate the interface. Students are encouraged to explore the site and discover all of the documents, resources, and tools available. Because Blackboard uses the graphical interface characteristics of the World Wide Web (and hypertext markup language), students meeting the "Internet literacy" prerequisite have little trouble navigating the course management interface.

Further, students in their first electronics laboratory course must learn to use the simulation software. Therefore, instruction in the use of Multisim must be part of the content of the DC circuits laboratory. Fortunately, today's students are familiar with graphical user interfaces, and Multisim uses the Windows interface. Its excellent on-line manuals help students get started. In addition, the technical content of the lab course itself often supports the introduction to Multisim. The simple introductory laboratories in most DC circuits courses allow students to start off with a simple voltage source, a resistor, and a meter. The "getting started" manual packaged with Multisim walks the student through building a similar simple circuit on the computer.

An unanticipated advantage of using Multisim in an introductory laboratory course is that the student's circuit has the same physical appearance as the "figure" in the lab manual or textbook. The components can be placed in a similar arrangement, and the wiring is "squared off" as it is in the picture. While collecting qualitative data during classes participating in research[2], we found that beginning electronics students occasionally spend an entire hardware lab session trying to build a circuit–never getting it right and never testing the concepts being presented in the lab. Students found this to be a tremendous waste of time and frustrating, and they appreciated the ease of constructing circuits in Multisim. This allowed them to get to the concepts being reinforced in the lab exercise.

The converse of this phenomenon is that more advanced students often learn from having to get a faulty circuit working. This is the one of two areas of technical content that must be addressed in this paper. Due to the nature of simulation software, students will not encounter broken test leads, open resistors, or shorted transistors. Everything will work properly assuming that the circuit is wired correctly. Beyond learning to troubleshoot a poor wiring job, students miss other "pleasures" such as finally discovering that the test lead to their voltmeter is broken. This leads immediately to a pedagogical discussion of when, where, and how engineering technology students will learn troubleshooting. Multisim provides for the teaching of troubleshooting by allowing the instructor to insert faults into most components.

Teaching troubleshooting using simulation software could be the topic of another paper. I will sidestep the issue in this paper with the following comments.

- Our qualitative research[2] indicates that unintentional troubleshooting efforts (such as discovering a broken test lead that should work properly) are unnecessary in introductory laboratory courses and frequently hinder the desired learning outcome.

- Most DC laboratory courses will include exercises in open and shorted resistors. Multisim can simulate these problems, which introduces elementary troubleshooting to the students.

- Instructors who wish to include more troubleshooting in any lab course may do so using the capabilities of Multisim.

The second area of technical content that must be addressed here is adapting the laboratory exercises themselves. At NSU, we use a published laboratory manual that accompanies the textbook for DC and AC circuits. Most of the DC circuits laboratory exercises in the lab manual can be performed in Multisim without modification. A number of the AC circuits exercises could not be performed exactly as written, primarily due to a limitation in the oscilloscope model in the older versions of Electronics Workbench. As a result, students were given alternate procedures to avoid known problems. [The oscilloscope available in Multisim eliminates a number of these problems.] Nevertheless, a word of caution is appropriate. Instructors should perform each experiment before assigning it to the students and provide additional instructions where necessary. Admittedly, an instructor in an on-campus course should also perform lab exercises ahead of class, but he or she could get by without doing so by being in the lab with the students and fixing problems as they arise. This is difficult to accomplish in an asynchronous on-line lab course.

2. EET Laboratory Course Pedagogy

Some of the issues addressed under "course content" could be pedagogical issues, too. Even so, this section of the paper covers a critical aspect of adapting a course for Internet delivery–how to teach the course rather than what to teach. It is here that adapting the course to the medium rather than trying to adapt the medium to the existing course becomes important. Fortunately, electronics laboratory courses adapt more easily to the environment than electronics lecture courses. Much of the typical electronics lab course pedagogy transfers readily to the Internet.

The methods that an instructor may use to adapt a laboratory course for the Internet will vary according to the technical content, the software used to deliver the course, and the desired course outcomes. To present the selected content of the DC and AC laboratory courses and achieve the chosen outcomes, I required the students to perform a number of tasks, which are listed below. The remainder of this section covers how these course requirements were accomplished using the Internet medium. Further, there are short discussions of course administration and communications.

The following tasks were required of students in on-line DC and AC circuits lab courses during the course of the semester.

- Use Multisim to perform the designated laboratory exercises
- Submit written laboratory reports
- Take quizzes on selected laboratory concepts
- Take a midterm and end-of-term test covering both theoretical concepts and laboratory procedures
- Take a comprehensive final examination

It may seem that the act of performing the lab exercises using Multisim would not be a pedagogical issue. However, an important outcome for students in an engineering technology program is learning to work in teams. In an on-campus course, we normally have students work in lab groups–a built-in teamwork exercise. A single student, taking an Internet course from a remote location will not have a lab partner unless one is assigned and groups are forced to work together. Electronic collaboration differs from face-to-face collaboration, and businesses use electronic collaboration more and more frequently. Assigning electronic lab partners in an Internet course makes good sense, and it is practical. While students may be required to perform individual exercises, there should also be group exercises. Blackboard provides support for group communications. The course administrator can establish any number of private discussion groups to allow lab partners to coordinate.

In the same way, laboratory reports can be individual or groups efforts. I normally use a mixture of both in the span of a semester course. Writing lab reports reinforces the technical concepts of the lab exercise and emphasizes written communications and teamwork. In my Internet classes, students have been allowed to submit lab reports using any of a variety of methods: Blackboard's "digital drop box," email attachment, facsimile, or in person. However, they are encouraged to use the digital drop box or email attachment method.

During the pilot on-line laboratory course, we discovered the advantages of using an electronic spreadsheet to prepare laboratory reports. It was suggested initially that students use a word processor to prepare their reports, because the documents could be easily sent electronically for grading. One student prepared a report using Microsoft Excel—rather than a word processor—due to its facility with tables. After that first attempt, we found that a spreadsheet not only produces outstanding tables and graphs of the experimental results but it also facilitates repetitive theoretical and experimental error calculations. By the semester's end, most of the students were using spreadsheets—with differing degrees of sophistication. The downside was that many of the students had to learn yet another software application (in addition to Electronics Workbench and Blackboard). However, once they were adept at manipulating their spreadsheet software, they loved its ease of use, the "automatic" formula calculations, and the professional results they achieved. Since the pilot course, students have been encouraged to use an electronic spreadsheet to prepare laboratory reports, which include tables for data and calculated values and incorporate graphs when appropriate. Text boxes are used for the written portions of the reports.

In addition to laboratory reports, I used quizzes to reinforce some of the concepts of individual lab exercises and tests–including the final examination–to measure student progress. Blackboard offers a number of ways to assess student performance, one of which is a quiz or test. Questions can be anything from multiple choice or fill-in-the-blank to open-ended responses by the students. The former can be machine graded, while the latter requires "hand" grading. Each of these methods work, and the instructor can choose his or her favorite methods. Overall, on-line testing pedagogy is not much different from in-class testing.

Due to the nature of the laboratory courses as compared with lecture courses, relatively few supplemental materials and course documents were provided other than the course syllabus and a sample laboratory report. Initially, announcements, which appear on Blackboard's opening screen for the course, and email were used to communicate with the students. Later, we discovered that Blackboard's built-in discussion board (an electronic bulletin board) was an effective way to answer questions from individuals and to allow all students to view the answers. Therefore, the discussion board has become an important communication tool in on-line laboratory courses.

Another pedagogical consideration is how much work is required and how often. Naturally, the answers to these questions depend on the instructor and the situation. The on-line laboratory courses at NSU are entirely asynchronous. The instructor posts information and assignments, and students complete the work when they have time available during the week. As previously mentioned, communications are also handled asynchronously using announcements, email, and the discussion board. I found that assigning one laboratory exercise per week in a semester-long course allowed me to cover all of the necessary experiments, yet leave time for introductory material and testing. I have tried several formats for graded student work. In each case, the students took two tests (one at midterm and one near the end of the term) and one final examination. During one semester, students were required to submit a laboratory report ***and*** take a quiz on each laboratory exercise. In another semester, students were required to submit a report ***or*** take a quiz following each exercise. The latter eased the grading and feedback burden on the instructor, but both methods seemed effective.

Finally, feedback–both feedback ***to*** the students on their work and feedback ***from*** the students on the course–is of particular pedagogical concern when presenting classes asynchronously and on-line. In many cases, it is likely that the students and the professor in an Internet course will never meet face-to-face. Instructors must take extraordinary measures to facilitate two-way communications with their students. It is incumbent upon instructors to communicate with the students on their progress. Graded labs should be returned, and the correct answers for tests and quizzes should be made available after the quiz has been completed by all. Blackboard allows immediate feedback during quizzes and tests by revealing the correct response to questions on the spot. After the pilot program, we disabled this feature because students could theoretically work together to get the correct answers before some of them attempted the test. At the request of the students, I began posting the answers to review questions found at the end of each experiment in the laboratory manual.

In addition to feedback on the technical content of the course, each semester I have administered an attitudinal survey, and I have requested personal feedback from the students about the conduct of the course. During the spring 2001 semester, NSU instituted a formal student rating system for on-line courses. The results of these student ratings are being provided to instructors and the administration for use in continuous improvement.

3. EET Laboratory Course Management on the Internet

For management of on-line courses, Northwestern State University uses Blackboard 5. Blackboard is adequate for the purpose, and it excels in some areas. Instructors can post information and assignments in a wide variety of ways. Students and instructors can communicate using discussion groups (similar to a "bulletin board"), chat rooms, and email. The assessment and grading modules allow a variety of testing and survey formats.

Several of the functions of course management have already been mentioned above during the discussions of content and pedagogy. Here aspects of course management are presented, but detailed discussion of some areas will not be repeated. In this section, the various facets of course management are grouped into three areas–getting started, two-way communications, and assessment.

All on-line students at NSU must contact the course instructor prior to the course starting date. This allows the instructor to provide instructions for getting logged into Blackboard. Students whose first electronics course is also their first on-line course require the most help in getting started. All NSU electronics students use Multisim–though not exclusively–in their lab courses. For the DC circuits laboratory, we assume that the students need instructions on Blackboard and on Multisim before they can tackle the technical content of the course itself. In subsequent electronics courses, we assume that students have learned to use Multisim. Exceptions can be handled as the need arises. Excluding the initial guidance for logging into Blackboard, all instructions on using Blackboard and Multisim are given in Blackboard itself. Blackboard's initial screen displays announcements, which are used to guide the students to further instructions and, eventually, to course material and assignments.

Communications are handled using a variety of methods, some of which have been mentioned. As Blackboard's opening screen shows announcements, those become the starting points for instructor-to-student communications. Announcements direct the students to course documents (such as the syllabus) and supplemental course material (such as a handout on significant digits or a sample lab report). They call the student's attention to new assignments that have been posted or tests that must be taken. The discussion board allows the instructor to answer student questions so that all students have access to the discussion. Email can be used to communicate directly with a single student or groups of students. Email is a good way to provide feedback to individuals on lab reports and other graded assessments.

Faculty assessment of the students and student assessment of the course have been discussed fully above. However, the subject of student cheating was mentioned only briefly and warrants further comment. For quizzes and tests, Blackboard offers random selection of questions from a test bank to keep students from seeing the same test. Establishing a test bank requires additional work on the part of the instructor, who may have to prepare 40 questions for a 20-question test. Requiring written submissions, such as individual or group lab reports, forces students to do enough individual work to ensure that their reports are different. Submission and grading of lab reports are essentially the same regardless of the medium used to present the course. In my own lab courses, all assessments are open-book, which removes any temptation for a student to use "illegal" sources. In addition, I ask students to certify (on the last question of every test) that they have completed the test without help from other persons. In any laboratory course, it is necessary to separate desirable and undesirable collaboration. On-line courses present new assessment challenges for instructors, but that does not make the medium itself undesirable.

IV. Successes and Shortcomings

1. Successes

Undoubtedly, the biggest success with our Internet courses is that we have made college-level electronics courses available to students who were previously unable to attend college. In our region of the state, there is a large population of prospective students who cannot attend college on campus due to family responsibilities, employment obligations, and travel distances. Yet, they could take college courses if offered at a convenient time and place. The Internet (especially the World Wide Web) provides that convenient time and place. Not one of the students who participated in our pilot program could have traveled to NSU for the two courses that they took during the fall semester. We know that there is a demand for our courses and our degree programs.

During the summer of 2002, we will offer our AC circuits courses on line. Because the EET program at NSU is small, many courses are offered in the fall or spring semesters only. The AC course is critical because it prohibits students who start college in the spring semester from proceeding directly to their advanced electronics courses the next fall. Offering the AC course on line during the summer not only will allow on-campus students to catch up, it also will allow off-campus students to continue their progress. An on-line course has an additional advantage of permitting students who must work full time during the summer for financial reasons to continue their education.

We have enumerated in previous paragraphs other successes that we experienced in offering courses over the Internet. We have discovered that many of the perceived barriers to going on line with electronics courses are just "obstacle illusions." Different presentation media require different approaches. Often we must be inventive and creative in our approaches. Those things that work in a classroom may or may not work on the World Wide Web. We found that trying various approaches led us to the more effective ones. Constant feedback from our students provided invaluable information in the quest to improve our delivery. Having students in the pilot courses with prior electronics training enhanced their ability to offer suggestions on the delivery of the technical content.

2. Shortcomings

One issue that NSU is grappling with as it expands its on-line course offerings is the dropout rate. One instructor (in another department) had a mere 10% of the originally enrolled students complete a one-semester course. Obviously, this is not acceptable. In our two electronics courses, 62.5% of the students enrolled completed the semester. Of those non-completers, only one did any coursework at all. The rest never started. For the same reasons given above, the sample represented by the students in our pilot program is not average. They were all "non-traditional" students, and most had previously received electronics training and had used Electronics Workbench. As we open our courses to all students, we will keep a close eye on completion rates.

Owing to the small size of the EET program at NSU, we have, out of necessity, presented four of our on-line courses in lieu of on-campus offerings. By doing so, we forced some on-campus students to take an on-line course. We have found that on-campus students are far more dissatisfied with on-line courses than are true "distance education" students. On campus students do not want to muster the extra self-discipline required of an on-line student. They prefer to be "told" to be in class at 9 o'clock each Monday, Wednesday, and Friday. As a result, the dropout rate of on-campus students exceeds the dropout rate of off-campus students. For many off-campus students, the Internet gives them their only opportunity to take college courses. For them, it is on-line or nothing. They accept the added discipline needed to be successful.

While Blackboard has many great features, it provides poor support for technical courses. It lacks a mathematics equation editor, and it does not recognize standard symbol fonts (for example, the Greek letters used so frequently in engineering and technology). It is cumbersome when posting figures that accompany electronics problems. As one might imagine, the assessments are well suited for multiple choice and matching types of problems and ill suited for free-form problem solving. The latter can be accomplished, but less easily. From our perspective, the Blackboard software still requires serious upgrades to become practical for mathematical, science, and engineering technology courses. The previously mentioned equation editor and symbol fonts are critical among the needed upgrades.

IV. Suggestions

We plan to continue to develop and present electronics courses and laboratories on-line. As we do this, we are working closely with our EET Industrial Advisory Committee. After initial reservations, the committee members realized the great potential of an on-line degree. In fact, they began to recognize the value to their own companies. Since our first discussion with the advisory committee, we have been contacted several times with questions of how soon we would be able to go on-line with an electronics degree.

As mentioned above, Blackboard is cumbersome when trying to present technical content in an electronics course. Nevertheless, there is a significant advantage to Blackboard. Once the material has been uploaded, it can be reused in subsequent semesters. Therefore, it becomes worth the extra time and effort to "do it right" the first time. The first time through a course will be tough while you are trying to adapt yourself to the new medium. But the following semesters will be much easier.

The Blackboard course management software gives students a consistent interface whether they are taking an electronics laboratory course or a psychology course from NSU. Nevertheless, Blackboard is not required to go on-line with a laboratory course. A professor at a school that does not support Blackboard or one of its competitors could still manage an on-line course. For example, a web page and email could accomplish much of the aspects of the on-line courses discussed above. While I do not recommend ignoring the local information system gurus, innovative professors could go on-line with little support from them.

Other suggestions have been included in the discussions of course content, pedagogy, and management above. Some of those suggestions are repeated here.

- Adapt the course to the medium rather than the medium to the course.
- Plan and schedule the semester to ensure that all course requirements are met.
- Include instruction on course management and the simulation software package.
- As soon as possible, establish good communications with the students. In the absence of face-to-face class meetings, students easily feel isolated. The instructor must keep the feedback flowing and the dialog going to keep the students satisfied.
- Consider using an electronic spreadsheet for preparing laboratory reports. [Note: this suggestion works just as well for on-campus laboratory courses.]
- Consider establishing lab groups and requiring electronic collaboration.
- Do the lab exercises yourself using the simulation software before assigning them. Sometimes, you get unexpected results. For example, some Multisim circuits require a circuit ground be inserted for the simulation to work properly.

One final suggestion if you are inclined to put electronics lab courses on-line:

Just do it!

Endnotes
* The most recent version of this simulation software is called Multisim 2001.
** The results comparing the two on-campus groups showed no significant difference based on a *t*-test. The two-tailed *t*-test results were $t(22) = -.024$, $p = .981$.
***The results comparing an on-campus group and an on-line group showed no significant difference based on a *t*-test. The two-tailed *t*-test results were $t(9) = -.183$, $p = .859$. (In this test, unequal variances were assumed.)

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