Delivering Electronics Engineering Technology Courses on the Web

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Abstract

Is it feasible to offer an associate's degree in Electronics Engineering Technology (EET) on the Web? The faculty in the Industrial and Engineering Technology (IET) Department at Northwestern State University (NSU) have begun planning to do just that. While the university has been proactive in distance education using a variety of media, going on-line with a program that demands extensive "hands-on" laboratory work has been greeted with both trepidation and enthusiasm. Much of the enthusiasm comes from our regional industrial partners, who seek to improve their workforce effectiveness through education. In the fall semester of 2000, we piloted the first two courses—a lecture and concurrent laboratory in DC circuits—on line. Four courses are planned for spring 2001. In this paper, we describe the courses that we are developing, the processes and procedures that we are using to go on-line, and some of the successes and shortcomings that we have faced. We conclude with some of the issues and challenges that lie ahead in expanding the pilot program to a complete degree offering.

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 criteria for accrediting engineering technology programs specify that theory courses "should be accompanied by coordinated laboratory experiences[1]."

Through our EET industrial advisory committee and other contacts, we have begun receiving requests to offer electronics courses on-line. In recent months, these requests have escalated, and now there is great interest in having an associate degree in EET available on the Internet. Nevertheless, offering an entire degree raises new issues—curriculum issues for the department and other issues that cannot be resolved within our own department.

In this paper, we discuss our experiences with offering EET courses over the Internet and the issues with expanding that effort to offer all the courses in an associate degree. We cover some of the successes and challenges and look at what the future may hold. We hope this effort will help others who are contemplating similar undertakings at their own institutions of higher learning.

II. Experiences to Date

Prior to offering the first on-line course, Hall[2,3] studied the effects of using simulation software for the conduct of EET laboratory experiments. In the initial effort, he compared groups of students who were enrolled in on-campus courses—a basic DC circuits laboratory course and an advanced device electronics laboratory course. He found that 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. The same research (with slightly different design) was restarted during the fall semester of the 2000-2001 academic year. This time the research involved not only two groups of students enrolled on campus in a DC circuits lab course, but also a group of students enrolled in the same course on-line. The two groups enrolled on campus 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. The on-line group did significantly better than the on-campus groups, but a statistical test is not relevant in this case because the on-line students were all employees from a single local industry and had previously taken non-credit, college-level electronics classes given by NSU. The on-line students were included in the research effort to collect attitudinal data for comparison with the on-campus groups.

The previous paragraph alluded to an on-line laboratory course. In fact, during the fall semester of 2000, we piloted the first two on-line electronics courses—a lecture course (ET 1300) and its complementary laboratory course (ET 1301) in DC circuits. In this pilot program, the on-line students were all employees in a single local industry. Most of them had previously taken non-credit electronics courses from NSU. The purpose of the pilot was to test the administrative and technical aspects of on-line electronics courses. Further, the company whose employees were registered for the pilot courses is very interested in working with us in putting our associate degree in EET on the Internet. Offering courses to a restricted group of students who had previous non-credit, but college-level electronics training allowed us to focus on improving the technical aspects of Internet course delivery while still providing college credit for the students. The lessons that we learned through this pilot project are included in the remaining sections of this article.

For development and management of on-line courses, Northwestern State University uses Blackboard 5 (an e-Learning software platform from Blackboard, Inc.). 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 e-mail. The assessment and grading modules allow a variety of testing and survey formats.

While it has many great features, Blackboard 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.

1. Experiences with EET Lecture Courses

Examples of "lecture" courses on the Internet abound. Formats and delivery methodology differ with different instructors, different media, and different course content. For our pilot course, the instructor used a combination of techniques that were available within the Blackboard platform. The fundamental course-delivery methods were reading assignments, homework assignments, quizzes, and tests. However, the instructor complemented these with supplementary notes, links to appropriate web sites, and practice problems. In addition, he established "on-line office hours" via an internal Blackboard chat room function, to be available to his on-line students in real time. By uploading entire documents to Blackboard, the instructor avoided the problems caused by the lack of a symbol font and an equation editor. Even so, Blackboard's weaknesses plagued his efforts to post tests and quizzes.

Because ET 1300 is the first electronics course that a student encounters in NSU's EET degree programs, the on-line instructor must also guide the students through the use of the Blackboard interface as well as provide the technical course content. As ET 1300 is likely to be the first on-line course that a student takes, he or she must spend some time learning to log in, navigate the interface, find the necessary information, and finally respond to the course requirements. All on-line instructors face this problem with students who have not previously used course management software (such as Blackboard). NSU has a number of professors who have previously taught on-line, and who are available to help new on-line instructors deal with this issue.

In the case of our pilot ET 1300 course, this problem was minimized by having all of the students available in one place, and by having a single point of contact at the local plant. There was always someone available at the distant end to help the students and to answer questions. We will not be afforded that luxury from this point forward. As we offer ET 1300 over the Internet to an "open" audience, we must contend with students who are new to electronics and who are first-time Blackboard users.

Despite the problems, we believe that the pilot delivery of ET 1300 over the Internet was successful. Partly due to their previous training, the students were also quite successful, when that success is measured in terms of their final grades in the course. We are offering ET 1300 over the Internet again during the spring 2001 semester—this time enrollment will not be restricted to a particular group. At the same time, we will offer another lecture course, ET 1320, in AC circuits. As with ET 1300, enrollment in ET 1320 will not be restricted any particular

group. As we move forward, and as we can be assured that the student populations are more homogeneous, we will be able to make better statistical comparisons between groups of on-line students and on-campus students.

2. Experiences with EET Laboratory Courses

ET 1301, Electrical Principles I Lab, was also offered over the Internet during the fall 2000 pilot project. The students enrolled in the laboratory course were the same students in the lecture course. For these reasons, most of the issues confronting the instructor and the students in ET 1300 could be reiterated here. Because of their previous experience, these students were quite helpful in working with the instructor on ways to improve the Internet delivery of an electronics laboratory course. The lessons learned are presented later in this article.

Like the students in the on-line ET 1300 lecture course, the students in their first laboratory course were trying to learn the Blackboard software as well as the course content. As you would suspect, the technical content of the laboratory course mirrored the technical content of the lecture course. These students, rather than learning to build circuits with actual components and to make measurements with test and measurement instruments, were learning to build and test circuits using simulation software. Contrasted with students of five or ten years ago, most of today's students arrive at college with adequate skills to operate a computer. Most have had experience with the Microsoft Windows operating environment. For them, Electronics Workbench is just another applications program. On the contrary, electronics test equipment is not commonplace in the home or in secondary schools. Hall[2] found that students generally felt that the simulation software was more conducive to reinforcing electronics theory than hardware labs. To justify their comments, students cited the relative ease of setting up the circuits, the visual aspect of the on-screen layout, and the precision of the answers. Often in the hardware laboratory, students would spend hours trying to get the test circuit to work properly. Their frustration would interfere with their ability to grasp the significance of the measurements they were trying to take.

The ET 1301 instructor used a slightly different methodology than the ET 1300 instructor to deliver this laboratory course over the Internet. For this course, the students used the laboratory manual purchased from the publisher of the lecture textbook, Electronics Workbench simulation software, and a word processor or spreadsheet. The primary learning instrument was the set of laboratory experiments that the students were required to perform using Electronics Workbench. Each week, the instructor assigned a laboratory experiment from the laboratory manual. Students were required to complete the laboratory exercise and to e-mail a laboratory report to the instructor. In addition, the students completed a ten-question on-line quiz after each laboratory exercise. The students took two tests and a final examination. The lab reports, quizzes, tests, and final examination were all considered in the final course grade.

Due to the nature of the laboratory course, few supplemental materials were provided other than the course syllabus and a sample laboratory report. Initially, the instructor used announcements, which appear on Blackboard's opening screen for the course, and e-mail to communicate with the students. Later, he discovered that the built-in discussion board (an electronic bulletin board)

was an effective way to answer questions from individuals yet allow all students to view the answers.

As Hall's earlier research[2,3] had suggested, the delivery of laboratory course over the Internet was as successful as laboratory courses in a hardware lab. Again, due in part to their previous training, the students were also successful. We are offering ET 1301 again during the spring 2001 semester and, like ET 1300, enrollment will be open. In addition, we will offer ET 1321, the AC circuits laboratory course that accompanies ET 1320, during the spring semester.

3. Experiences with Mathematics and Basic Science Courses

The current EET associate degree curriculum requires that students take two six-hour mathematics courses—MATH 1810, Technical Mathematics, and MATH 2020, Calculus for Electronics. Technical mathematics combines college algebra, trigonometry, and introductory statistics, while the calculus course teaches concepts of differential and integral calculus. Students who come to the EET program with credit for college algebra and trigonometry are given credit for MATH 1810. At the time of this writing, there is no simple substitution for the six-hour MATH 2020. Currently, the Department of Mathematics at NSU offers a three-hour college algebra course over the Internet. Trigonometry and calculus are not available. In addition to the math courses, the associate degree in EET requires PHYS 2030, General Physics, and PHYS 2031, the accompanying laboratory. Neither of these courses is available on-line.

Naturally, mathematics courses must be available (and available early in their program) to the associate degree students if they are to complete a degree on-line. We are working with the Department of Mathematics, and with the Department of Chemistry and Physics, to determine how we can best satisfy these requirements. This issue is discussed further in a later section of this article.

4. Experiences with Communications and Humanities Courses

Finally, to complete the associate degree, students must take three communications courses (Composition and Rhetoric I and II, and Technical Writing) and one humanities course. NSU has offered these four courses over the Internet in past semesters, and it will continue to offer them. Therefore, the communications and humanities segments of the associate degree requirements present no obstacles to offering the degree over the Internet, and they will not be discussed further.

III. 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.

We have enumerated in previous paragraphs other successes that we experienced in offering our first two 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 with prior electronics training enhanced their ability to offer suggestions on the delivery of the technical content.

Specifically, the instructor of the on-line lecture course found that Blackboard's course chat room allowed students to have real-time access to him. The real-time aspect of the chat room allows students to "hear" the answers to questions and to ask follow-on questions quickly and easily. The lab course instructor used the bulletin board for similar purposes. There are subtle differences between the two approaches. The chat room "meets" at a specific time (or times) during the week. It allows greater interaction among the participants. At the same time, it also means that every student who participates in the chat must be free at the specific time. This negates one of the advantages of using the Internet for course delivery. Further, it becomes difficult to find a time that accommodates all or most of the students. The bulletin board is less interactive, and it may introduce time delays in getting questions answered. Even so, the questions and their answers remain visible for every student to view—regardless of the time.

During the semester, students in the laboratory course discovered the advantages of using an electronic spreadsheet to prepare laboratory reports. Initially, the instructor had suggested that students use a word processor to prepare their reports, because the documents could be easily sent electronically for grading. (While students were allowed to submit lab reports by facsimile, they were encouraged to use attachments to e-mail message instead.) 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, almost all 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.

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.

Beyond this, we experienced a number of technical problems. Technical shortcomings such as these should be expected when one is on the leading edge of technology. Within the State of Louisiana, Northwestern State University is far ahead of other universities in putting courses and curricula on-line. We have reviewed and have experimented with several on-line course management and development software packages. Blackboard is the second such package that we have used extensively, and we have used it for only two years. Many of the technical problems with the Blackboard software are discussed in prior paragraphs. We experienced even more fundamental problems with its stability and with its technical support. Some of these problems will diminish with time and software upgrades. Further, NSU technicians made some changes, which improved the responsiveness of the platform. For example, by putting Blackboard on a separate server, they significantly reduced the downtime and increased the accessibility. Other strange technical problems are still being addressed. For example, the system seemed to be very unstable when it was accessed through certain Internet Service Providers.

Finally, 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. Looking to the Future

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.

Meanwhile, both the faculty and the members of the industrial advisory committee are concerned about the lack of hands-on experience when a degree offered is 100% on-line. Together, we have started exploring possible solutions to that problem. We are considering several possibilities. One potential answer is adding an on-campus "hands-on" course to the on-line curriculum. There are many ways to "deliver" such a hands-on course, but we must take care not to lose the very people we wish to attract—those who cannot travel to campus for classes.

In addition to "hands-on" experience with laboratory test and measurement equipment, there are other issues regarding the curriculum, which we are addressing. Because the sections of our mathematics service courses are normally small, it does not make sense to offer both on-line and

on-campus sections. We are considering different and innovative solutions to this problem. Further, we are struggling with the delivery of the General Physics Laboratory course on line. At the time of this writing, we have just begun working with the Department of Chemistry and Physics on creative solutions.

We have discovered that departments whose primary responsibility within the university is to provide service courses for other degrees have a different view of putting courses on line than do departments whose primary responsibility is to produce graduates. For those of us who primarily produce graduates, on-line courses and degrees provide the means to reach new audiences. We see new and dedicated students and the possibility of expanding our programs. Other departments see the burden of teaching an old course in a new way with little reward for doing so. One solution for us is to reach beyond the limits of our own university. NSU participates in the Electronic Campus of the Southern Regional Education Board. Certain courses offered by other SREB Electronic Campus members could be used to satisfy courses in our curriculum.

V. Summary and Conclusions

We believe that we are looking at the future. We believe that we can put an associate's degree in electronics engineering technology on the World Wide Web. We believe that we can produce graduates who are just as successful as the graduates who are currently finishing our on-campus degree program. And by any measure, those graduates are quite successful. We are excited about the possibilities, and we are energized by the challenges that lie ahead.

Endnotes

[*] The most recent version of this simulation software is called Multisim.

[**] The results comparing the two on-campus groups showed no significant difference based on a *t*-test. The two-tailed *t*-test results were $t(22) = -.024$, $p = .981$.

Bibliography

1. Accreditation Board for Engineering and Technology (ABET). 2000. "2000-01 Engineering Technology Criteria." [cited 03 January 2001]. [On-line]. Available from http://www.abet.org/downloads/2000-01_Engineering_Technology_Criteria.pdf

2. Hall. Thomas M. 2000. [A qualitative analysis of] Using simulation software for electronics engineering technology laboratory instruction. *2000 ASEE Annual Conference Proceedings*. St. Louis: American Society for Engineering Education.

3. Hall. Thomas M. 2000. A quantitative analysis of using computer simulation software for electronics engineering technology laboratory courses. *Journal of Engineering Technology*, Fall 2000.

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