AC 2011-2158: USE OF TECHNOLOGY TO ASSIST AND ASSESS DISTANCE STUDENTS IN INTEGRATED ELECTRICAL ENGINEERING COURSES

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Use of Technology to Assist and Assess Distance Students in Integrated Electrical Engineering Courses

Abstract

The University of Wisconsin-Platteville has been attempting to make undergraduate education more accessible to nontraditional students through distance education. As part of this plan, our department began offering their electrical engineering (EE) program in the fall of 2008 to students located at all the two-year schools within the state system. This distance program allows place-bound students to complete their entire four-year program on a part-time basis at the two-year school. The electrical-engineering faculty have been trained in the best practices for distance education and have utilized technology to create office hours for remote students which are essentially equivalent to face-to-face office hours.

One of the strengths of our electrical engineering program has been that all but one of our courses has had an integrated laboratory component. In addition, most courses have required significant design projects. Distance students to date have completed their labs at their local two-year school instead of traveling across the state to main campus. Lab instructors have been hired to provide equipment and lab support for these courses. This lab approach with an on-site lab instructor has been serviceable for "cookbook" type laboratories, where all the instructions are provided, and low-level design projects.

Alternative approaches have been investigated for use with higher-level laboratories and design projects. Technology has been selected to assist students in trouble-shooting their laboratory projects and to assist them with design-related questions. Techniques have been developed to allow instructors to remotely assess understanding of laboratory concepts and completion of project requirements. These techniques have been tested with students in core courses to allow instructors to assess student lab work and to obtain student feedback. Best practices are discussed.

Background

As institutions of higher learning search for ways to cut costs and become more efficient, more classes are being offered via distance education. In engineering this method of delivery has been widely used in graduate courses for lecture-based courses, but has been relatively rare on the undergraduate level until recently. This has been especially true in electrical and computer engineering (ECE) as was demonstrated in a 2005 study of 126 institutions that had either electrical engineering (EE) or computer engineering (CE) programs[1,2]. Although 30 percent of these institutions offered some online degree program in engineering, only 18.3 percent offered these programs in EE or CE (82.6% Master's programs). Only one online undergraduate EE program existed at the time of the study.

The reason that undergraduate electrical engineering programs have lagged behind some other engineering programs in adopting online methodologies is twofold[3]. First, electrical engineering is one of the most mathematically intensive majors, making it less desirable to offer the entire major online. Second, hands-on laboratories are a mainstay in undergraduate EE programs, which are extremely difficult to incorporate in an entirely online manner.

Recent improvements in technology have significantly reduced the first barrier to offering distance undergraduate electrical engineering courses online. Web-conferencing software has enabled better communication with distance students during office hours. Initially this software was used as a continuation of the classroom. The instructor would do examples and the students would respond with further questions (by audio or texting)[4,5,6]. Communication is further enhanced if the student also has the capability to interact in written form through the use of Tablet PCs or pen tablets in combination with the web-conferencing software[7]. Since students are not always good at verbalizing their questions, this technique allows both the student and the instructor to share and write on the same electronic piece of paper. In addition web conferencing software such as Adobe Connect Pro allows the instructor to share documents and application software. The instructor can even give the student the ability to run applications remotely on the instructor's computer, allowing for troubleshooting of software application problems and remote assessment of student computer skills[8]. Using this technology, remote students have access to equivalent office hours to those taking the course live which up until recently was a major restriction to offering the electrical engineering degree online and opens up the possibility of offering even the most mathematically intensive courses (such as Electromagnetic Fields and Signals and Systems) online.

Laboratories, the second barrier to offering an electrical engineering program at a distance, are much harder to address. Initially some faculty surmised that they could overcome this problem through the use of virtual laboratories.[9,10,11,12,13,14] There are several difficulties with this approach. First, these virtual laboratories are labor intensive to develop making them expensive in terms of either faculty development time or money invested in 3rd party hardware/software. Second, our programs need to deliver and achieve the same learning and outcome objectives for our remote students as they do for our traditional students.[1] Finally, by making the laboratories virtual the students do not develop the necessary skills for designing, constructing, and troubleshooting circuits. To address these problems, equipment has been developed that provides the functionality of standard laboratory test equipment (power supply, signal generator, and oscilloscope) but with virtual software control and display. LabVIEW, a graphical programming environment created by National Instruments, allows the creation of virtual control panels and output displays for instruments on computers. Since much of the cost of test equipment is associated with the control and display aspects of the device, much simpler and more cost effective hardware interface modules can be created that are more efficient in terms of space and are much less expensive.[15] National Instruments offers a commercial version of this interface by the name of NI-ELVIS which serves as a platform for very specific test modules.[16]

An alternative approach is to provide each distance student with the standard laboratory instrumentation that is available on main campus. While this approach is more in line with traditional EE education it has its own problems. Lab equipment needs dedicated space, something lacking at many remote sites. Lab equipment is also costly, requiring a base level of distance student enrollment to justify the expense. Last, but certainly not least, such labs need to be staffed to provide technical assistance for students and to maintain the functionality of the lab equipment.

Hybrid Electrical Engineering Distance Education Program

Hybrid courses may be defined as a combination of online and traditional instruction. Using this definition, hybrid courses can take various forms.[8,17] The hybrid model used in the College of Engineering, Mathematics, and Science (EMS) at the University of Wisconsin-Platteville combines asynchronous lectures and on-site face-to-face lab offerings. The different aspects of our distance electrical engineering courses are discussed below.

Streaming Video Lectures (Asynchronous)

At the request of local industry, the University of Wisconsin-Platteville began offering their undergraduate electrical engineering program in the fall of 2006 to place-bound students at two strategic locations within the state. This collaborative program was established to allow non-traditional students, who work during the day, to complete their entire undergraduate degree on a part-time basis in the late afternoon and evenings without having to travel to main campus.[18] On-site faculty have provided the majority of course offerings, supplemented by an occasional distance offering.

In the fall of 2008, this program was expanded to allow engineering students at any of the thirteen two-year schools within the University of Wisconsin System to complete their engineering degree remotely. These courses are offered using streaming video (SV) technology (asynchronous). This methodology was selected to accommodate the different schedules of students within the program. The streaming video lectures are posted within 20 minutes of the completion of lecture allowing distance students to watch the lecture at their convenience.

In 2008, the EE faculty applied for and received a Committee on Baccalaureate Expansion (COBE) grant to allow faculty to be trained for distance education. The first training session occurred in the summer of 2008, which emphasized technologies involved with faculty delivering lectures to place-bound students via streaming video and setting up an online presence using Desire2Learn (D2L) for the class webpage. Local experts from our Distance Learning Center, Media Technology Services, Learning Technology Center, helped faculty to learn the new technologies and shared best practices. A follow-up training session during the summer of 2009, concentrated on the effective use of technology to improve distance office hours and labs. Instructors received training on the use of Tablet PCs, which are provided to each faculty member that offers a streaming-video course.

D2L Webpage and Office Hours for Remote Students

A course D2L webpage was actively utilized for all streaming video offerings. Course information, announcements, assignments, examples, homework solutions, laboratory projects, grades, and links to the SV lectures are all available on the course website. Instructor calendars and contact information are also available on this site. Initially, some faculty placed their completed lecture notes on the class website in advance. More recently, faculty have placed skeleton lecture notes (partially completed lecture notes including equations, figures, and blank spaces for in-class notes) on the class webpage. This encourages the students, both local and distance, to be more active during the lectures.

Weekly online office hours are established for each student. Some faculty set common office hours for all streaming-video students; others set regular office hours for each student individually (if the number of distance students is relatively small). Initially Skype was used for office hours. Students would communicate questions via audio or email and then the instructor would use a webcam to complete examples or clarify specific points. However, we found that in practice the resolution of the cameras were typically inadequate. More recently, faculty have been utilizing Adobe Connect Pro®, web-conferencing software, that allows two-way communication and sharing of whiteboard space, documents, and applications. This software even allows the instructor to share control of his/her desktop allowing the instructor to oversee application of any program (PSpice, Matlab, CAD, etc.) and provide feedback. Currently all streaming-video students not located at a collaborative site are provided with a tablet-PC for the semester, allowing them to better communicate with instructors on the shared electronic whiteboard. Students at the collaborative sites who take SV courses have access to pen tablets instead. The reason for the difference is that at the collaborative program sites there are dedicated EE program computers which contain course specific software. For students at other remote sites (without dedicated EE program computers), course specific software is loaded onto the tablet PCs prior to the start of the semester. The university is currently working on a centralized password protected software system allowing students the ability to use software remotely. Once this is in place, the less expensive pen tablet technology will likely be utilized by all SV students[7]. Our current office hour implementation combining Adobe Connect Pro and two-way written and audio communication has been viewed as positive by our students in recent surveys and course evaluations.[7]

On-site lab offerings

Laboratories play a major role in our electrical engineering curriculum. All but one of our EE courses (Electric and Magnetic Fields) have an integrated laboratory component. Faculty teach both the lecture and the laboratory portions of the class (no teaching assistants). Most of our courses have significant design projects. The laboratory aspect of our curriculum was highlighted as one of the strengths of our program during our last accreditation visit. In our entry level courses, laboratories are used to verify theoretical concepts and to teach the operation of basic lab equipment. The laboratories in Circuit Modeling II, a transition course, are focused on conceptual understanding and are used to introduce basic design. In higher level courses, laboratories are focused on design.

Due to the integrated nature of labs in our curriculum, the local EE faculty resisted the adoption of distance education. The collaborative programs were supposed to be taught face to face with an occasional technical elective being offered via distance. Since students would be learning the laboratory fundamentals face to face, we thought that the offering of a few technical electives would be manageable.

With the administrative decision to make the entire EE curriculum available via streaming video to remote portions of the state, the EE faculty was forced to look at our curriculum and determine how we could offer an equivalent version of courses to remote students. Faculty also searched the literature and internet for distance education models for the laboratory portion of electrical engineering. Our search resulted in two model types. Programs that required their students to physically come to main campus to complete their labs (either on weekends or in the summer) and programs that employed virtual laboratories combined with "cookbook" labs. Neither approach fit our needs. The latter approach could only be used for introductory courses. Nor is it feasible for working students to travel across the state to complete their labs. As a result, we decided to bring the labs to the student. Agreements were made with the two-year campus sites to host on-site laboratories during the semester. A lab assistant from main campus would arrange lab times with students, bring and set-up lab equipment, and serve as a resource during the completion of the laboratories at these regional sites.

Assessment of SV students in Lab

As with most new programs, the streaming-video-only program began gradually. Face-to-face lectures offered locally to students either on main campus or at one of the collaborative sites were recorded for students enrolled in the SV section of the course. The initial cohorts of SV students began with the low-level courses and have been steadily moving through the core offerings. As a result, we have been allowed to develop the curriculum for streaming video a few courses at a time instead of all at once.

Since the number of SV students per class is still small, faculty have been able to try different approaches to facilitate distant student learning. The selected assessment techniques used in the lab depends upon the level of the course and are consistent with those used in our face-to-face offerings. For entry-level courses such as circuit-modeling I, traveling support staff can be used to assess proper usage of lab equipment and to evaluate the construction and performance of simple circuits. As the design content of the course increases, the assessment responsibility falls on the course instructor. For example, during the fall of 2010, Analog Electronics was offered via streaming video for the first time. All laboratory projects in Analog Electronics were design projects. Local students were required to have one-on-one preliminary design meetings in the instructor's office. To accommodate this requirement for streaming video students, D2L and Adobe Connect Pro were used. Students submitted all design files and scanned handwritten work to a D2L dropbox. Online meetings were then held with each of the streaming students. When necessary, the online meeting permitted the instructor to edit Spice files and other documents to assist the students with their designs.

The students were required to demonstrate their successful designs to the instructor in the laboratory. Handling this requirement for the streaming video was done through technical support staff. The instructor trained the staff member how to evaluate each design, and the staff member traveled to the location of the streaming video student to view the demonstration of the design.

Each faculty member teaching a SV course selects an aspect of the course that they want to improve during a given semester. In fall 2010, the faculty member who offered the SV section of circuit modeling II wanted to address a laboratory problem he had observed last time that he offered the course (face-to-face). Upon the completion of the laboratory, students are required to complete check-off. Check-off is a short question and answer session with the instructor in which the student demonstrates they have completed all the requirements and met all of the specifications. It is also used to assess a student's level of understanding. Instead of completing the check-off immediately after the completion of the lab, the faculty member had the student complete the results section of their report first, which allowed students time to evaluate their data and improve conceptual understanding. Upon completion of check-off, the students were provided a brief amount of time (couple of days) to complete their final report.

Check off for Circuit Modeling II SV students was conducted online using Adobe Connect Pro web-conferencing software. Students would submit either the completed results section from their report or individual scope traces and figures in advance. These documents would be shared during the online session and the student would answer a series of questions to evaluate their understanding. For example, in a first-order circuit lab a symmetric square wave signal was input to a simple RC circuit at two different frequencies as shown in Fig. 1. The students were asked to explain the waveforms that resulted (part of their grade for check-off). After receiving feedback, the students completed and submitted their lab reports. The faculty member found that the discussion sections in lab reports for that semester were much improved because of this change. These improved lab reports become a resource for the students to use in the future.

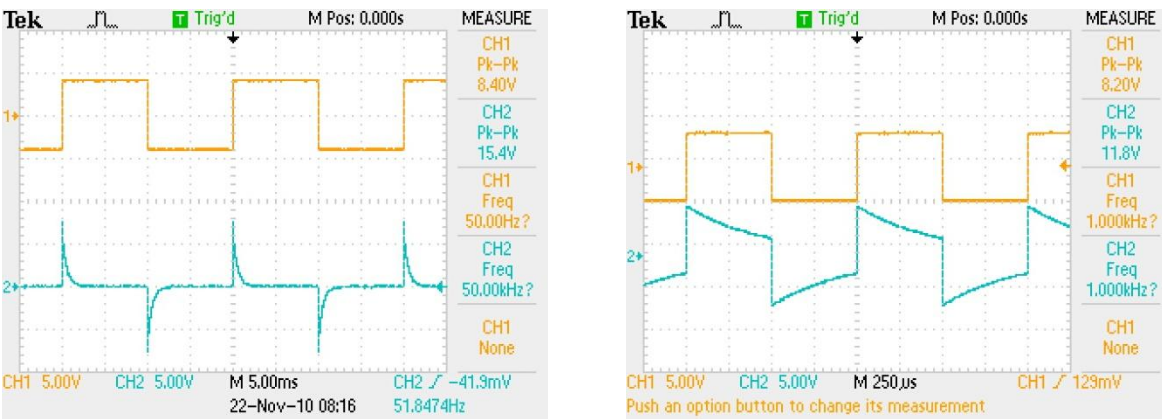

Fig. 1 Response (blue) of a simple RC circuit to a symmetric square-wave (yellow) input for two different frequencies

In response to problems with student preparation for lower-level labs, a couple of faculty members have recently adopted pre- and posttests for each laboratory project. The pretests consisted of either a set of questions based on the reading material for the laboratory or a set of calculations that must be completed and submitted prior to entering the lab. The posttests involved either short answer or a series of calculations and/or simulations to demonstrate that the student met the objectives of the laboratory project and can relate the measurements made in lab to the theory discussed in class.

Collaborative and SV Program Success

The collaborative four-year EE programs, which started at UW-Rock County and UW-Fox Valley in 2006, have graduated a total of four students (BS EE) to date. The ME program, which began at UW-Fox Valley in 2002, has delivered 46 BS ME students. An ME program was started at UW-Rock County in 2008. As of fall 2010, the collaborative programs (EE and ME) had a combined total of 77 active students with 203 students in the pipeline.

To date we have had only one student obtain their degree delivered entirely through the streaming video program (BSME), however this population is steadily growing. Since its inception in 2008, over 200 students have completed SV engineering courses originating either from main campus (UW-Platteville) or the two collaborative sites (UW-Rock County and UW-Fox Valley). As of fall 2010, we had 31 active SV-only engineering students in the EE and ME program combined with at least 7 in the pipeline.

Best Practices

Over the last three years nine of our eleven EE faculty have been trained to offer streaming video courses.[18] This training mainly addressed the administrative and lecture delivery portions of SV courses. Each trained faculty member has taught at least three SV courses to date. These courses are supplemented by a D2L webpage which provides student access to the streaming video lectures, course information, faculty contact information and calendar, assignments and due dates, examples, laboratory projects, and additional links. We have built a web site in order to share our experiences at http://www.uwplatt.edu/ee/ee_dis_edu/index.htm. A summary of our findings is provided below.

Distance students need to be informed about expectations when they enter the program and again for each course including timely communication with faculty, proctors, and lab assistants. Exam proctors and times need to be set at the start of the semester. Specific lab times need to be established early in the semester, especially if you plan to employ the mobile lab approach that we use. Students should have a single location (class webpage) for all course content. This site should include a detailed class schedule (with due dates), announcements, assignments, examples, solutions, laboratory projects, grade information, and links to the SV lectures. Instructor calendars and contact information should also be available on this site.

For office hours we have found that web conferencing software such as Adobe Connect Pro is essential for providing interactive whiteboard space and allowing document and application sharing. Students should also have either a tablet PC or a pen tablet which allows two-way written communication on a shared electronic piece of paper (essential for mathematically intensive courses). It is important to meet will all SV students for online office hours at the beginning of the semester to make sure they are comfortable with the technology. In addition, regular office hours for individuals or small groups need to be established to make sure students have access to assistance. If your students are primarily evening distance students, it may require the instructor to shift their work schedule in order to accommodate these students.

Instructors for SV courses need to allocate additional time for technology. Instructors need to show up for class in advance to make sure the equipment is working correctly and may have to stay after class to upload content to the course webpage. All handouts need to be posted in advance on the course webpage. All assignments should be submitted in electronic form to an electronic dropbox (preferably on the course website). Instructors should also have access to a Tablet PC not only for lectures, but also for electronic grading purposes.

For introductory-level labs, having lab kits is something that can be beneficial[19]. Graded prelabs are useful to make sure students have read the lab in advance (problem for lower level labs) and that a student is prepared to begin the lab (essential for design labs). Post-lab quizzes/assignments can be useful to assess laboratory objectives and relationship between laboratory measurements and theory. Recorded lab demonstrations can be used to help both local and SV students to properly utilize test equipment.

For higher level courses with more involved design projects we have been looking into methods to improve our ability to troubleshoot remotely. In addition to the use of web-cams, we are investigating ways for faculty to directly access the displays of bench lab equipment (via labview or hardware specific software). We are currently working with the SV sites (two-year schools) to set-up space for a basic lab bench that students could regularly access.

Bibliography

1. Wael Ibrahim and Rasha Morsi, "Online Engineering Education: A Comprehensive Review," *Proceedings of the 2005 ASEE Annual Conference*, Portland, OR, June, 2005.
2. "Entering the Mainstream: The Quality and Extent of Online Education in the United States, 2003 and 2004," Sloan-C and the Sloan Center for OnLine Education (SCOLE), 2004
3. Bourne, J., Harris, D., and Mayadas, F., "Online Engineering Education: Learning Anywhere, Anytime," *Journal of Engineering Education*, Vol. 94, No.1, p. 131-146.
4. Charlie P. Edmonson and Scott Segalewitz, "A Blended On-line Engineering Technology Course Using Web Conferencing Technology," *Proceedings of the 2005 ASEE Annual Conference*, Portland, OR, June, 2005.
5. J. Crofton, J. Rogers, C. Pugh, K. Evans, "The Use of Elluminate Distance-Learning Software in Engineering Education," Proceedings of the 2007 ASEE Annual Conference, Honolulu, Hawaii, June, 2007.
6. M. Plett, D. Peter, S. Parsons, and B. Gjerding, "The Virtual Synchronous Classroom: Real Time Off-Campus Classroom Participation with Adobe Connect," Proceedings of the 2008 ASEE Annual Conference, Pittsburgh, PA, June, 2008.
7. Dale N. Buechler, "Can Pen Tablets be used to improve the Performance of Place-Bound Engineering Students?," *Proceedings of the 2010 ASEE Annual Conference*, Louisville, KY, June, 2010.
8. Mark Holdhusen, "A Comparison Of Engineering Graphics Courses Delivered Face To Face, On Line, Via Synchronous Distance Education, and In Hybrid Formats," *Proceedings of the 2009ASEE Annual Conference*, Austin, TX, June, 2009.
9. Oguz A. Soysal, "Computer Integrated Experimentation in Electrical Engineering Education over Distance," *Proceedings of the 2000 ASEE Annual Conference*, Saint Louis, MO, June, 2000.
10. G. Gerdin, "Virtual Instruments for Distance Learning," *Proceedings of the 2002 ASEE Annual Conference*, Montreal, Canada, June, 2002.
11. Charles Nippert, "Evaluating Student Performance in Online Laboratories," *Proceedings of the 2002 ASEE Annual Conference*, Montreal, Canada, June, 2002.
12. Paul I-Hai Lin, Hal Broberg, and Aik Mon, "A Web-based Lab for Distance Learning," *Proceedings of the 2002 ASEE Annual Conference*, Montreal, Canada, June, 2002.

13. M. Kostic, "Sampling and Aliasing: An Interactive and On-Line Virtual Experiment," *Proceedings of the 2003 ASEE Annual Conference*, Nashville, TN, June, 2003.
14. Keith E. Holbert and Mihaela M. Albu, "A Signal Processing Laboratory Employing On-Line Teaming for Remote Experiments," *Proceedings of the 2003 ASEE Annual Conference*, Nashville, TN, June, 2003.
15. Mani Soma, Bee Ngo, Jessica Yan, Richard Christie, and Eve Riskin, "Hands-on Circuit Design and Test Laboratory for Distance Learning in Electrical Engineering," *Proceedings of the 2004 ASEE Annual Conference*, Salt Lake City, UT June, 2004.
16. Carlo Sapijaszko and Genevieve I. Sapijaszko, "An Innovative Electronics Laboratory System for On Campus and Distance Learning Applications," *Proceedings of the 2004 ASEE Annual Conference*, Salt Lake City, UT June, 2004.
17. Michael Reynolds, David Paulus, "The Best of Both Worlds: Hybrid Learning," *Proceedings of the 2009 ASEE Midwest Section Conference*, Lincoln, NE, Sept. 2009.
18. Dale N. Buechler and Liya Ni, "An Electrical Engineering Program for Place-Bound Students: The First Two Years," *Proceedings of the 2008 ASEE North Midwest Section Conference*, Platteville, WI, Oct., 2008.
19. J.M. Long, J.R. Florance and M. Joordens, "The Use of Home Experimentation Kits for Distance Students in First-Year Undergraduate Electronics," *Proceedings of the 2004 ASEE Annual Conference*, Salt Lake City, UT June, 2004.