An Electrical Circuits Hybrid Course Design

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Abstract - As computer technology becomes an important tool in the modern classroom, most engineering technology educators struggle with the best approach for incorporating these tools within a technology course that has a laboratory component. Some instructors resist the use of web technology completely, while others find ways to use the technology as a course enhancement tool; however, one of the most challenging considerations to the instructor is whether a technology course with a lab component, such as electrical circuits, can fit an online course model. Fitting a traditional engineering technology course with a lab component into an online course model appears to create challenges in the development of hands-on skills. The research question seeks to establish that a hybrid course model, which integrates an online lecture and on-campus laboratory experience, is a suitable course format. A basic DC/AC circuits course is structured using a hybrid model.

Keywords: hybrid, online, circuits

MODEL DEFINITIONS

Traditional Model

To avoid defining various methods of instruction used within the classroom, the traditional model for a technical course in this paper will be defined as a course that contains face to face contact with the instructor in the lecture and laboratory environment. There are no limitations to the instructional methods used within this face to face interaction.

Web Enhancement Model

Web enhancement covers a broad spectrum of capabilities and flexibilities for a course. This brief discussion on enhancement tools is not comprehensive. In some cases, web enhancement may be defined as simply access to internet capabilities within the classroom. However, the broader sense of the term includes the use of a course management system for managing different aspects of the course while retaining the traditional course pedagogical model. Schmidt [6] suggests that a web enhanced course provides one of four basic components: administrative, assessment, content delivery, and community.

Some of the web enhancement tools available through many course management systems include provisions for giving students access to various course files (administrative), access to electronic quizzes and exams (assessment), access to a discussion board for various topics selected by the instructor (community), access to additional instructional audio or video tools (content delivery), submission of course material electronically, such as laboratory reports and homework (administrative), and even course communication capabilities through an email server (community) [6]. Although these tools seem to suggest an online course format, the tools are simply used to enhance the traditional course while retaining the freedom of direct contact with the instructor during a lecture and laboratory period.

Online Model

An online course model emphasizes that all student activities are performed through the internet with no face to face contact with an instructor. This model integrates all the features of the web enhanced model and expands these tools to include an electronic lecture or some form of electronic activity to replace the face to face component of traditional and web enhanced course models. The online course model is complicated in a technology course by the need for laboratory access. Further, the student cannot develop the dexterity skills provided by the use of measuring instruments, calibration tools, and physical access to equipment.

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The proposed solution for meeting the hands-on laboratory requirements for a technology course is the virtual laboratory [4, 7] and the remotely operated laboratory [2, 3, 5]. The virtual laboratory might utilize some form of computer software to emulate equipment, system operation, and data measurement. Weisner and Lan have demonstrated virtual lab success for the chemical process industries but do not diminish the importance of "tactile" skill development [7]. Progress is being made in this area of study, particularly with courses adaptable to software simulations. The obvious advantage to the virtual lab experience is a reduction in the cost of lab equipment and measuring tools. Unfortunately, there are manual dexterity skills that cannot be developed through the virtual environment. The primary goal of a technology course is to train students on concepts as well as develop skill sets. For example, in an electrical circuits course, the student should become familiar with the theoretical concepts of Ohm's law, but just as important, the student needs to become comfortable using a voltmeter and ammeter to demonstrate this theoretical principle. An employer will have the expectation that the student being hired knows how to use these tools.

Remotely operated laboratories have shown promise for the distance learning environment [2, 3, 5]. A remotely operated lab is simply a physical laboratory accessed from a remote site. A remotely operated lab must utilize a variety of instruments, such as cameras for visual feedback, measuring instruments for data feedback, and even sound equipment for the audio experience to duplicate the in-person laboratory experience [5]. Since the equipment is not being monitored locally, the laboratory system under study must incorporate additional safety measures that are not always required with a locally operated lab. Clearly, the remotely operated laboratory requires an expense for the initial set up, as well as the continued operation and maintenance of the equipment; however, under an asynchronous schedule, only one setup would be required which could offset the cost of the system [2]. Ogot, Elliott, and Glumac demonstrated a successful remotely operated lab as applied to a jet thrust laboratory [5]. The laboratory configuration met the needs of a mechanical lab experience; however, the requirements in a circuits lab involves many wiring configurations and movement of instruments throughout the circuit. The student interaction with different wiring configurations develops an important dexterity skill for the electrical student, which would be absent using the remotely operated lab model. An alternative approach to a remote lab requires the student to have access to both software and hardware for performing the hands-on component and publishing data to the internet [3]. This form of a remote lab may be limited in the complexity of labs that can be performed; however, it could be adaptable to a circuits course if the hardware and measuring equipment required to perform a circuits lab could be made available to each student.

The virtual and remotely operated laboratories have some potential for helping the student understand theoretical principles; however, at this point, the student is still missing the manual dexterity development without handling the measuring devices and interfacing with the circuit.

Hybrid Model

The hybrid course model is a method of incorporating both an online component and on-campus component for the course. This model may take on different forms according to the type of course and the intent of the learning outcomes of the instructor; however, for the technology course explored in this paper, the hybrid model will incorporate an online lecture and an on-campus laboratory experience.

The core of this model utilizes many of the enhancements provided by the course management software with the addition of a lecture component. The student is required to watch and listen to lecture material, similar to the delivery format provided in the classroom. The recording may include a video file or simply an audio file, or a combination of the two. The course model proposed uses a presentation software, Micro-Soft (MS) Power-point, to outline the lecture material. Each lecture slide has been narrated by the instructor. In addition, the lecture file includes links to video screen-shots of example problems worked on a PC writing tablet. The video screen-shots are performed with a free software package by TechSmith called "Jing" and a workspace provided by MS Paint. In order to integrate the various forms of media presented, and to provide a compression of the lecture file, a software tool known as Impatica is utilized. The resulting file has various navigational tools to enable students to move easily through the lecture (see Figure 1). In order to view a lecture, students are required to have a high speed internet connection, a web browser, a flash and shockwave reader, and the latest version of Java loaded on their own computers. Since the compressed files average 2-3MB, a student without a high speed connection is allowed to upload the lectures to a memory storage device while on campus for viewing at home.

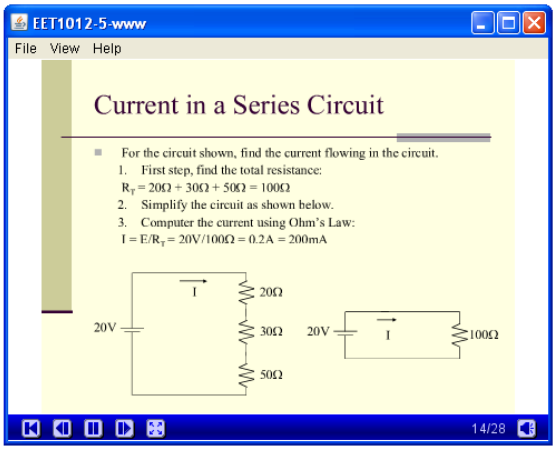

Figure 1 – Sample lecture file.

The course homework sets are available in an online format through the assessment tool of the course management system. Each homework problem is randomly selected from a database of questions that fit the topic. The problems in specific sections of the database are equal in difficulty level, so the randomly selected questions are fairly distributed. The homework problems are structured in two basic formats, T/F and multiple choice. An example of the online homework is shown in Figure 2. The student is able to access the homework at any time and can navigate in and out of the homework as often as necessary. Once the student has completed the homework, the work is submitted for a grade. Figure 3 illustrates a video screen-shot of an example problem available to the students through the course management system. Each video screen-shot is narrated by the instructor. These screen shots are intended to assist the student in completing the homework assignments.

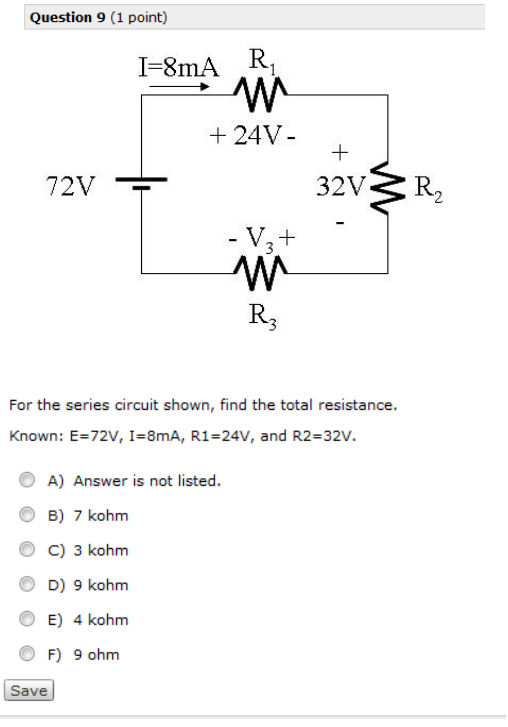

Figure 2 – Sample multiple choice homework problem.

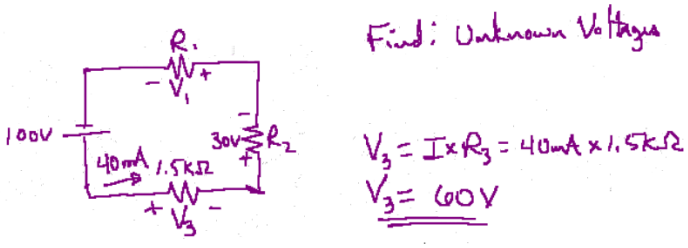

Figure 3 – Sample video screen-shot of a narrated homework example

The discussion board of the online course management system is available for students to post questions about specific problems. This tool is structured with multiple topics according to the chapters being covered as shown in Figure 4. The intent of this structure is to ensure the communication threads are limited and confined to the topic of interest. In addition, the students are able to contact the instructor through email when struggling with a problem. One other form of communication used in this model is the course management system announcement page. The announcement page is a great tool for notifying students of an upcoming exam or a change in the course schedule.

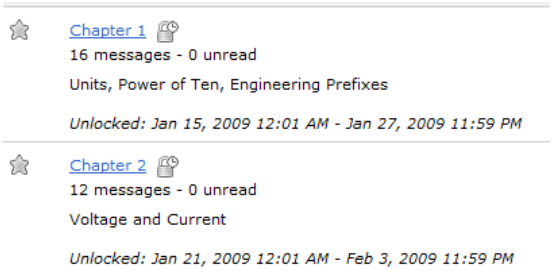

Figure 4 – Links to the discussion Forum

The student is assessed over the material covered with online quizzes and paper exams. These activities are offered during the laboratory class meeting period to ensure that the activity is proctored. The quizzes are online to facilitate efficiency and immediate feedback to both the student and instructor. The exams are paper exams which allow the instructor to see the student's work and thought process during problem solving.

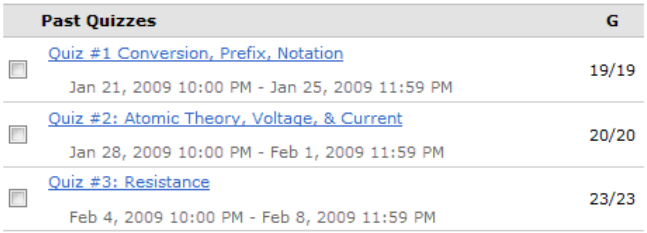

Figure 5 – Links to assessment tools for the 2009 semester

Laboratory assignments are performed during the class meeting time each week. A lab report is required from each student. The student is required to drop the lab report file into a drop-box feature of the course management software. The drop-box feature is illustrated in Figure 6.

Dropbox Folders

20 per page

	Folder	Total Files	Unread Files	Flagged Files	End Date	Actions
	No Category					
	Lab Report #1	39	0	0		
	Lab Report #3	22	0	0	Feb 11, 2009 6:15 PM	
	Lab Report #4	22	0	0	Feb 18, 2009 6:15 PM	

Figure 6 – Links for the drop-box folders

Although the course is not using a virtual lab, the hybrid course requires the student to purchase a student edition of Multi-Sim, a software package that can simulate electronic circuits. The software provides the student an additional tool for verifying homework solutions. In addition, the instructor can assign a variety of simulation homework problems to further enhance the student's understanding of circuit theory.

The laboratory experience in the hybrid course is identical to that in a traditional course. The student performs each experiment on-campus, under the supervision of a lab instructor, utilizing measuring equipment similar to that used in industry. The primary advantages of this lab format are the development of hands-on skills expected of employers and the face to face time that students have with the instructor.

Data Summary

Electrical Circuits at PSCC

During the spring semester of 2009 and 2010, a hybrid electrical circuits course was offered at Pellissippi State Community College (PSCC). The traditional course offering had been scheduled to meet twice per week in an evening format with lecture meeting one evening and lab meeting the other evening; however, with the hybrid format, the course was designed to meet only once per week for three hours during the traditional laboratory time slot.

Data used to evaluate the effectiveness of the hybrid course comes from four sources. The primary data is the student performance in the hybrid course compared to student performance in a traditional course (Figures 7-10). However, student input is important to improve the course components and to gauge where students are investing their time. Data collected through a formal survey of students enrolled in a hybrid electrical circuits course during the fall of 2011 is used to gauge student attitudes toward different components used in the course. In addition, data from student perceptions collected during the spring 2010 semester are referenced. Finally, informal discussions and interviews with students and instructor observations on how to improve the course are included.

During the spring 2010 semester, eighteen out of twenty-nine students enrolled completed a student perception survey. Fifty-five percent of the students gave the course an overall rating of "Good" to "Excellent." Twenty-two percent of the students expressed dissatisfaction. According to student comments, those dissatisfied expressed frustration over the amount of time invested outside of class and lack of face to face contact with the instructor.

The expectation of the hybrid course was to have students watch the lecture during the week prior to attending lab and begin working on the homework assignment. Subsequently, the student could ask questions through the discussion board or through email when the student was not grasping the concepts. Some students utilized these tools, while others chose to wait until the class meeting to get questions answered. During the 2009 and 2010 semester, a brief 30-45 minute question session was offered at the beginning of the lab session to make sure the students were staying on track with the assignments and getting their questions answered.

From the online course management system, there is a feature that tracks student access to course management activities, such as accessing the online lecture files. Data has shown that the students spend time viewing the lectures; however, there was no consistency with how much time is spent with each lecture. In the spring 2010,

twenty-two of twenty-eight students accessed eight or more lectures out of sixteen total lectures. A survey conducted with students enrolled in a hybrid circuits course indicated that 56.3% of the students spent 1 hour each week watching the lectures, while 68.8% indicate that the embedded video files were helpful. The difference between those who accessed the video files and those who actually spent time watching the video lectures is about 13%. This data seems to indicate that 13% were simply accessing the screen-shot video example problems. This data supports informal student interviews conducted outside of normal class activities in which some students indicated that they only looked at the video examples. Although the recorded lecture is suitable for some learning styles, the student survey indicated that 93% of the students prefer a face to face environment for lecture.

The communication forum was the weakest link for the hybrid course. Some students used the online discussion forum, but most students preferred to communicate directly with the instructor via email. A brief student survey indicates that 93.5% of the students do not use the online discussion forum. According to the statistics from the discussion board counter, the students rarely use the discussion board throughout the semester. Although the students prefer email to communicate when seeking help with a problem, the other students in the course did not get an opportunity to see what question was asked and how the instructor answered the question. The communication activity must be improved for this course to engage all learners.

The online homework was developed primarily to make certain students were doing homework throughout the week. When the students were initially assigned homework in their textbook during the 2009 semester, only a handful came to class each week having attempted any of the homework. Most of the students were waiting until the following week to begin the homework. In addition, the homework credit was based on a completion percentage. When the homework went to an online format, the student's grade was directly proportional to the number of correct answers. All the homework assignments were placed online. Once the online homework was initiated, the instructor could identify which students had accessed the homework. In addition improving the grading mechanism increased the number of students engaged in homework. According to a student survey taken after the online homework was instituted, 87.5% of the students spent between 1-2 hours on homework each week. The same survey indicates that over 70% of the students found the online homework to be beneficial to their learning. An interesting result is that the majority of students preferred the online homework to working the problems from a textbook. Since the instructor was with the students only once per week, the students needed to be engaged in homework prior to the weekly face to face meeting in order to resolve homework questions. According to the student survey, a weekly homework session is needed with the hybrid course.

Comparing an electrical circuits course in the hybrid format to that of a traditional format reveals some deficiencies. The number of failing grades issued in the hybrid course for the spring 2009 and 2010 semester totaled 8 of 52 students compared to 4 of 55 for the traditional course offered in the 2008 and 2009 fall semesters. The percentage of failing grades was the most significant difference among all the other grades as shown in figure 11.

Fall 2008 Data			
Start %	Symbol	Frequency	
0	F	1	3.4%
60	D	2	6.9%
70	C	5	17.2%
78	C+	6	20.7%
83	B	5	17.2%
88	B+	5	17.2%
93	A	5	17.2%

Figure 7 – Fall 2008 traditional course grade distribution.

Fall 2009 Data				
Start %	Symbol	Frequency		
0	F	3	11.5%	
60	D	4	15.4%	
70	C	1	3.8%	
78	C+	3	11.5%	
83	B	3	11.5%	
88	B+	4	15.4%	
93	A	8	30.8%	

Figure 8 – Fall 2009 traditional course grade distribution.

Spring 2009 Data				
Start %	Symbol	Frequency		
0	F	5	20.8%	
60	D	3	12.5%	
70	C	2	8.3%	
78	C+	3	12.5%	
83	B	2	8.3%	
88	B+	1	4.2%	
93	A	8	33.3%	

Figure 9 – Spring 2009 hybrid course grade distribution.

Spring 2010 Data				
Start %	Symbol	Frequency		
0	F	3	10.7%	
60	D	2	7.1%	
70	C	3	10.7%	
78	C+	5	17.9%	
83	B	6	21.4%	
88	B+	4	14.3%	
93	A	5	17.9%	

Figure 10 – Spring 2010 hybrid course grade distribution.

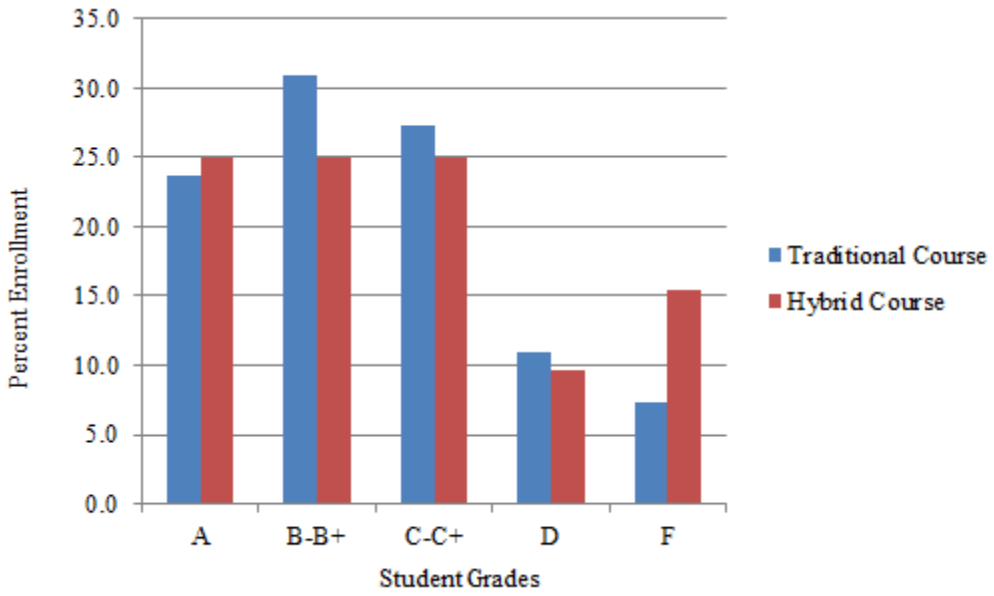

Figure 11 – Traditional course scores (blue) vs. hybrid course scores (red).

There were several noticeable factors that may have influenced the students' performance. Those students with failing grades in the hybrid course did not watch all of the lecture material. One student accessed eight out of sixteen lectures, and the others accessed fewer than six. Four of these eight students did not complete all of the work required for the course, such as quizzes, homework, and exams. The other four students completed all of the work required but did not have sufficient success on the assignments. In addition to the lack of success on assignments, the failing students did not utilize the instructor's office hours or arrange a separate time to obtain instructor help.

One final observation from the data collected from the hybrid courses offered in the spring of 2009 and 2010 relates to the performance of non-traditional students compared to traditional students. For the purposes of this paper, the non-traditional student is defined as being twenty-five years of age or older. The traditional student is defined as being under age twenty-five. As shown in figure 12, 35% of the non-traditional students earned an "A" whereas

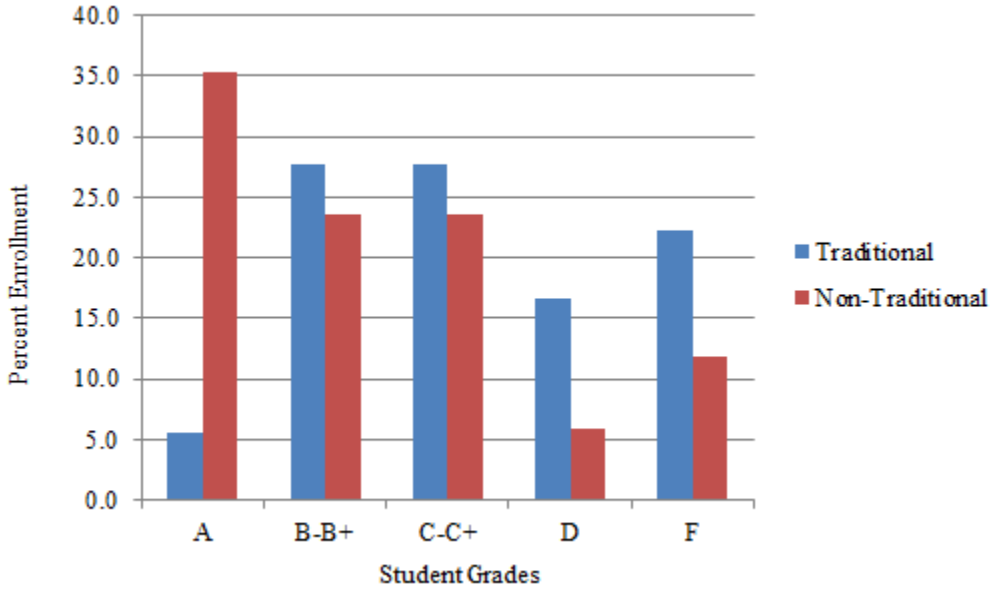

Figure 12 – Traditional student performance (blue) vs. Non-traditional student performance (red).

only 5% of traditional students earned an "A." In addition, a smaller percentage of non-traditional students received a failing grade. This data could suggest that the hybrid course is more suited to the non-traditional student.

CONCLUSION

Analyzing circuits is an important skill for an electrical engineering technology student to develop during the first year of study. This course forms the foundation for student success in courses that follow. This study revealed that the current format has several positive features along with a series of deficiencies that need to be resolved, such as:

(1) Improving student interaction during the week;

(2) Developing a simpler lecture format or incorporating an equal activity to better engage students;

(3) Adding more pre-recorded video screen-shot examples;

(4) Adding short answer problems to the homework database (currently under construction).

A less desirable improvement is to increase the student-instructor contact time by 1 hour to improve the problem solving session. Although this improvement is beneficial to the student, it violates the spirit of the hybrid design of minimizing the student-instructor contact time. Unfortunately, this modification is a direct result of a failure of students to have weekly interaction with classmates and the instructor through the course management system.

The experience of working with a hybrid course also revealed some positive features, such as the pre-recorded video screen-shot examples and the online homework, which both appealed to the students. In addition, there are other advantages to the hybrid course design that touches a variety of audiences:

(1) The classroom is occupied for one class period per week, which allows the room to be used for other courses when classroom space is a premium;

(2) The student is on campus once per week for the course, which appeals most to non-traditional students;

(3) The student develops the necessary dexterity skills required by employers through a traditional lab format.

Overall, the course was reasonably successful and a great deal was discovered through the process. As pointed out by Ernst [1], the success of online education begins with the faculty commitment to the pedagogical model, particularly, with assessment. Quality assessment is the key to improving the hybrid course model. At the same time, the student must also demonstrate a commitment to the process. As with any new course or course format, the hybrid course model will continue to undergo changes as technology improves, and as experience is gained through future course offerings.

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