A Successful Model for Web-Based Engineering Technology Education

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"How does one go about teaching a student to ski
using the Internet as the only medium for training?"

This is the question I first asked when the department of Engineering Technology, William States Lee College of Engineering, UNC Charlotte, made the commitment to make its upper-division baccalaureate degree programs in Fire Safety Engineering Technology and Electrical Engineering Technology available to students via the Internet. As a card-carrying holder of the old-school "chalk-and-talk" lecture paradigm, the task of teaching the skills that are associated with these types of skill-based programs without face-to-face contact seemed initially daunting at best and impossible at worst. Is the Internet not a sound-, text- and graphic-only medium? How does one address the different learning styles of students? How does one demonstrate mastered skills through such a narrow window of communication? How does one maintain academic integrity? Who is going to spend the tremendous amount of time developing materials? What format will the materials use? Can engineering skills be successfully learned over the Internet?

These were the questions of this very skeptical old professor, and as those questions rapidly accumulated without any definitive answers, we as a faculty simply said as a body, "we'll make it work," and sealed the commitment to offer the programs. This approach to design is truly an engineer's dream and an educator's nightmare. It is a challenge for any engineering educator.

At the time of this writing, the department is completing its second year of web-based instruction following four years of two-way audio/video distance education instruction. The department policy requires that resident and non-resident students must receive the same education. Consequently, we have a basis for comparing these student groups, and the initial results might be surprising. Though the attrition in the distance education program is expectedly higher than the resident program, so is the level of the performance of its students. When subjected to the same set of performance tests, those students who participated in the Web-based curriculum consistently outperformed the resident students who took the same classes at the same time. Furthermore, because of the nature of the contribution that the Internet made to the courses, both the two-way video cohort and the Web-based cohort outperformed similar resident classes of previous semesters that lacked the Web-based resources. Therefore, the model used to create this environment might be of interest to some in the education community. The model presented here will be descriptive of two courses offered in the first year of the program: ETEE3183, Digital Logic Designing with Programmable Logic Devices and ETEE3285, MC68000 Assembly Language Programming. Though these are not SKIING-101, the courses require many demonstrated skills.

The Problem.

The learning of a skill traditionally requires some form of master-apprentice relationship with the master demonstrating the skill and then supervising the developing efforts of the apprentice. The apprentice must then work on the skills. Following the period of practice, the apprentice then demonstrates the skill to the master and achieves the appropriate guidance and reward. Teaching over the Internet necessitates reducing much of that relationship to the context of the dialogue box on a computer screen, a rather narrow portal of vision. The demonstration of skills over such a medium becomes a challenge. To do so, some paradigm changes may be necessary. *It is through the detailed and deliberate translation of traditional teaching models to the Internet context that success can be attained in Web-based education.* Teaching also involves addressing the varied learning styles of students. At worst, the Internet may be used as a reading medium, suiting only the visual learner. The materials that are translated to this context should be provided to the student in a way that will address as many learning styles as is possible.

The Software.

There are several vendors of course management software that provide an excellent foundation for building a Web-based course. These programs manage a database of instructional web pages that are developed by the training institution (probably the instructor), the interfaces between the participants, and facilities for the assessment of student progress through the administration of on-line testing. In presenting its programs, the department has used three packages, each containing its own strengths: Centra® (www.centra.com), WebCT® (www.webct.com), and TopClass® (www.wbtsystems.com). Complete descriptions of these products can be obtained from their respective web pages listed here. Various Microsoft Office® tools were used to prepare content including FrontPage®, PowerPoint®, and Microsoft Word®.

The Lecture.

Most engineering professors are "chalk-and-talkers." We stand before a class of students with a writing instrument in our hands, a surface to write on, and a voice to narrate the writing process. It is not a difficult task to translate these processes to the digital environment of the Internet. However, that translation can be excruciatingly time-consuming, particularly if the course is to be taught asynchronously: that is, students will have access to the materials at any time they choose and without the instructor's interaction. Anything that can be written on a black/whiteboard can be digitized, and anything spoken to a class can be recorded, so the translation is not impossible. As the content expert, the instructor will usually execute this task.

The board-work of the two courses discussed here was translated to PowerPoint® slides. However, rather than the stereotypical bulleted text slides that we see so many times at conferences, the context of skill-based courses necessitates far more creativity in slide design. Design skills are taught on a blackboard by the progressive disclosure of the components of that design. This method can necessitate the development of many graphically intensive slides. The digitization of the board work of each course described here required no less than 10,000 slides. This translates to about 5 slides per minute. This rapid rate is a product of the progressive disclosure method where very little content changes between slides, often amounting to no more than the movement of an arrow. The slides also included over 1000 complex figures per course.

The slides were organized into instructional modules that mirrored the lectures taught to resident classes. In the semester prior to the Internet presentation, the slide set was used to teach the resident students in lieu of the traditional board-work. While the lecture took place, the audio portion of the lecture was recorded using the "record narration" function of PowerPoint®. The instructor wore a portable microphone and repeated questions asked by the students. The product of this effort was a library of audio/visual slide presentations with each representing a complete lecture, or instructional module. The only "post-processing" that was necessary was the division of each module into smaller logical components, so that the lectures could be consumed in shorter instructional pieces. Each component would run from ten to twenty minutes, closer to the attention span of most students than the original 80-minute lecture.

Finally, the slide presentations were recorded onto compact discs (CD-ROMs) that are distributed to the students at the beginning of the semester. Lectures are viewed off-line on any computer outfitted with the free PowerPoint Viewer® software and a sound card. Students have complete control over the viewing: able to fast-forward, repeat, stare, etc. while their families still have the use of their telephones. Lectures were also provided on-line, but the advantages of the CD-ROMs reduced the on-line lecture usage to near zero. Use of the CD-ROM also eliminates the bandwidth limitations of the Internet. The sound and graphic quality provided to the student is limited only by the respective resolution of the student's computer.

It may be interesting to note that courses in the Fire Safety Engineering Technology program also make use of the synchronous lecture capabilities of the Centra® software. Similar in presentation to that listed above, the slides are broadcasted by the instructor to students who are logged into the Centra® server. As the instructor speaks over the slides, all students can hear, and when outfitted with a microphone, can ask questions. The instructor has control over the student's microphones and manages the answering of questions. The sessions are recorded so that absent students can replay the lectures.

The Homework.

The key to success in learning a skill is in its practice. The podium-based lecture presentation model only addresses the visual and aural learning styles. It is difficult to learn skills by simply watching and listening. The "chalk-and-talk" instructor will often provide homework in the form of a series of assignments that must first be completed by the student and then be submitted for grading. Some time after submission, the students receive their graded work that may later be used for review. This mechanism, though used by the majority of teachers, may provide very little interaction between the student and his/her work. Also, because of the delay in receiving instructor feedback, its usefulness is limited. The course management programs provide a new tool for the instructor that can be a great improvement upon the old paradigm. Homework assignments that were once relegated to a printed sheet are translated to the Internet context via the use of the testing facilities of the course management software. Often, the result of skill-based endeavors can be illustrated with written answers. Where information-based classes can often take advantage of computer-graded multiple-choice questions, skills may be assessed using short answer questions. For example, a short answer can be "**-2.875 volts**", "**X=!A&B&!D**", "**MOVE.B D0,-(A7)**", etc. The skills represented in these examples include electronic circuit design, logical circuit design, and assembly language programming.

The translating of assignments to this context can be a real paradigm bender and can consume great amounts of time and require some real creativity on the part of the designer. However, once translated, a whole new phase of interaction takes place between the student and their homework. When an assignment is submitted, the course management software can grade it and return the results to the student immediately. I provide students a five-day assignment window within which the components of design problems may be submitted. Upon receiving computer-graded results, the students may then correct their errors and resubmit the assignment for a higher grade, provided they have not exceeded the five-day submission period.

This interaction between the student and the computer-graded homework has seemingly contributed to some startling results. The average score on the same performance tests for students enrolled in the combined Fall 2000 and Spring 2001 Web-based classes was a full letter-grade (11.2 points) higher than the resident classes taken the year before using the instructor-graded worksheets. However, the variance is not entirely due to the homework interface. Students enrolled in the Internet classes work full-time and are typically more mature than those enrolled in resident classes. Also, the higher attrition of the Internet class eliminates the contribution to the average by poor and marginal students who do not survive in this environment where success is directly predicated by self-discipline.

Consequently, to test the effectiveness of the homework interaction alone, the mirrored year 2000 – 2001 resident classes submitted their assignments over the Internet along with the Web-based sections. In this population, the resident classes outperformed the previous year's sections by only 5.2 points, and were still soundly trounced by their Web-based counterparts. One year of data does not provide enough information to draw any significant conclusions other than answer the big question: "Can skills be taught over the internet?" In this case, the answer is a resounding, "Yes," and this professor is no longer skeptical.

The Course Interface.

Figure-1 illustrates one of the primary screen images that is present when a student is interacting with the on-line course management system. Both TopClass® and WebCT® utilize a two-frame window where the left frame is an index into the content frame on the right. This sixteen-week course has two 80-minute modules per week, organized as 28 instructional modules, two exams, and a three-hour final exam. The content frame of Figure-1 illustrates the typical activities that will be engaged by a student in a single instructional module.

Line 1. This is a title line for the module, and is a link to a page that provides complete instructions for completion of the module. The link also includes a database of answers to questions that are frequently asked concerning the content of this module.

Line 2. This is a link to the set of PowerPoint® presentations for this module. This 80-minute lecture, described above, can be viewed on-line, and is made available to students off-line using a CD-ROM. Because of this latter facility, the on-line lectures are rarely viewed, and can probably be eliminated.

Lines 3, 4, 5, 6, 8, and 11. These are links to web pages that contain text and graphic material that supplements the course and textbook. It may include example worked problems and

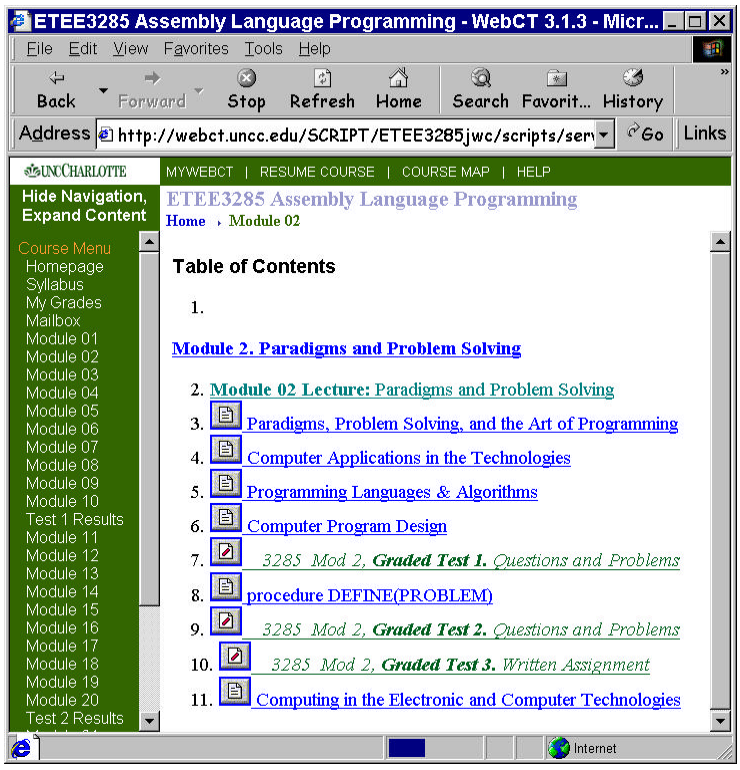

Figure-1. WebCT® Screen Image

pedagogic instruction. The student, prior to attempting to complete the tests, should review these links. Some students who are aspiring tree-killers tend to print all of these pages, a practice that should be discouraged.

Lines 7, 9, and 10. These lines are links to the tests that will be completed during the five-day submission period that this module is assigned. Most tests are organized as a series of short answers that describe a completed design process. Test pages are usually printed by the students and completed off-line. Students then go back on-line and submit their answers. Consequently, little on-line time is actually needed in order to interact with the course.

Several modules contain "Self-tests" that are optional, and are not included in the student's homework grade. These are particularly useful when the text and lecture do not provide enough worked examples to provide enough illumination for those students who need a little extra help.

Exams and Academic Integrity.

One of the first questions that arise when one considers Internet-based education concerns the integrity of the academic contribution made by the students. The student who receives the credit for the course must be the same student who did the work. In order to maintain academic integrity in the homework and exams, a two-pronged approach was employed. First, examinations are given twice during the semester, and a comprehensive final exam is provided at the end. These exams are proctored by a volunteer who assures that the student taking the exams is indeed the correct person, and that the rules surrounding the exam are followed. This

individual is often a member of the training unit at the student's place of employment. It is critical that this proctoring is done with integrity. Furthermore, since these are skill-based courses, those students who cheat on the homework will do poorly on the proctored tests, so their inflated homework grade (only 25% of the overall grade in my classes) will be more than compensated by the lowered exam grades.

Workload

It is probably quite evident that a great deal of time is required to develop the materials in this model. The digitization of the lecture materials can be a daunting task, and must be done prior to the recording of the lectures. Since these lectures were recorded before a live resident class, the development process took a minimum of two years. While the course is being offered on-line, the primary avenue of communication with students is limited to Email and Instant Messenger formats. During the first semester that students interact in this manner, each student initially contacted the instructor an average of two to three times each day. On-line office hours were established, but it was convenient for the instructor to interact with the students outside of those posted hours. Consequently, four to six hours of each day was dedicated to communication with distance-education students, a number far greater than that dedicated to a typical resident class. In order to deal with this additional load, the department of engineering technology at UNC Charlotte established a policy of providing a single course release in a semester prior to the offering of a web-based course for the purpose of curriculum development. Then, while a web-base course is being taught, the workload attributed to that course is double that of a resident section, effectively providing another course release. This is a real and necessary expense to the department that must be considered when implementing a Web-based course delivery.

Student Opinion

All students who participated in the distance-education sections of the courses submitted an anonymous questionnaire. Their responses were very positive, with few criticisms and many suggestions for course improvement. Several of these suggestions are being implemented in the current offerings of the courses.

Students were asked to rate on a scale of 1 – 5 (with 5 being full agreement) their opinions on some of the properties of the course:

- The homework had a very positive impact on my learning: 4.58
- I liked the lecture presentation style: 4.33
- Internet delivery course is better than a resident delivery course. 2.71
- I was able to learn the course concepts in this environment. 4.42
- The availability of the internet-based course was very beneficial to me. 4.63
- The technology used to present the course impeded my ability to learn. 1.66
- I highly recommend this course delivery method. 4.38

Students also indicated that they spent an average of over five hours reviewing the CD-ROM lectures each week. This is greater than the three hours spent in lecture by resident students due to the ability to replay and pause the CD-ROM PowerPoint® presentations.

Conclusion

This article describes the model for implementation of two skill-based upper-division engineering technology courses over the Internet. These courses are part of the offering of the complete upper-division 2+2 baccalaureate degree program in engineering technology by UNC Charlotte. After two years of curriculum development, the courses were offered to a new cohort of distance-education students. The model applied very well, and the students who completed the courses out-performed their resident peers by five to ten percentage points, a statistic that is attributable primarily to the student's interaction with the homework interface and their ability to review the CD-ROM-based lectures. This combination of reading texts and slide materials, listening and watching the lectures, and interacting with the homework interface served to address the wide range of learning styles preferred by a broad student body. The student's responses to the course were very positive. One should note that those student responses were provided at the end of the courses when many of the poorer performing students had dropped out of the course. The attrition rate was about 40% after the first semester, with another 10% dropping during the second semester of the four-semester program. As a result of this experience, some recommendations can be made to those who are considering implementing a Web-based course delivery.

Some very informative examples of Web-based course delivery concepts and content can be found at http://www.webct.com/faculty.

Recommendations:

- Skill-based engineering courses can be effectively taught over the Internet if sufficient preparation of the materials is made and the students are forced to interact positively with those materials.
- It may take anywhere from five to ten hours to prepare the materials for a one-hour Web-based lecture module. Because of this, preparations for a Web-based course should start at least a year in advance of the Internet offering.
- As the content expert, the faculty member will produce most of the Web-based course materials, with some assistance from available course delivery software specialists.
- If possible, the Web-based materials should be offered to resident students as a "dry-run" to make adjustments to the materials prior to committing them to the on-line environment.
- A workload release should be provided to a faculty member who is in the process of developing a Web-based course.
- Another workload release should be provided to a faculty member who is presenting a Web-based course.
- Enrollment of students into an Internet-based course should be limited to those who cannot take part in a resident program since the sole advantage of the program is its physical separation from the teaching institution.
- A student's success in a Web-based course is predicated by their self-discipline. The primary deterrent to course completion is procrastination. A student will also have to dedicate more time to this type of course than is typical for a resident course.

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