Don't Just Tell Me, Show Me!
Presenting a Microelectronics Course Completely on the Internet

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Abstract

Challenges to effectively delivering distance education (DE) courses, particularly web-based individual access (IA) DE, such as lack of instructor access, isolation, and removal of peer interaction are well recognized as common throughout all disciplines. Considerations such as increased self-discipline and the additional planning and effort required in communicating questions, problems or concerns must be recognized and addressed to allow the IADE student to successfully complete course requirements. In spite of these obstacles, distance education is a valuable tool that allows students, who would not otherwise be able to avail themselves of the opportunity, to attend classes and receive an accredited degree.

Additional difficulties arise for technically oriented courses, particularly in the engineering disciplines. Engineering courses are often computationally intensive and require the ability to generate graphic representations at various levels of problem abstraction. These courses, which are considered difficult for traditional, on-campus instruction, must now be presented effectively to the IADE student entirely through the Internet medium. The challenge in teaching these courses effectively is to provide complete representations of the different levels of abstraction required, along with as much class interaction as possible.

In the Active Networks series offered by the Engineering Technology Department at the University of North Carolina at Charlotte, course requirements involve the modeling of microelectronic devices and circuits based on physical and operational properties and the use of these models in the design and analysis of systems using these devices. A variety of synchronous and asynchronous delivery and interaction mechanisms to provide support and enable students to comprehend and appreciate this crucial component in the study of electrical engineering technology are employed. The approaches taken in the successful delivery of complex concepts and, most importantly, student mastery of course material are the focus of our discussion in this paper.

Introduction

Difficulties students encounter with distance education (DE), particularly web-based individual access (IA) DE, such as lack of instructor access, isolation, and removal of peer interaction are well recognized as common throughout all disciplines. There are several challenges inherent in what is essentially an independent study that must be recognized and addressed for the student to complete the course successfully and, what is actually more important, realize the knowledge and

skills that will ensure future professional success. Considerations for successful completion of IADE courses may include, but are not limited to: [1,2,3,4,5]

- More self-discipline is required to get through lecture material than a traditional class (but, on the other hand, lectures or topics may be broken up and the student may and progress at an individual pace as long as defined deadlines are met).
- The student does not get the benefit of personal, face-to-face interaction with the instructor and classmates and is more dependent on written material to attain necessary knowledge and skills.
- Communication between students and instructor for questions, problems and concerns cannot be immediate and, as a consequence, may require more planning and effort.

Additional difficulties arise for technically oriented courses, particularly in the engineering disciplines. Engineering courses are often computationally intensive and require the ability to generate graphic representations at various levels of problem abstraction. These courses, which are considered difficult for traditional, on-campus instruction, must now be presented effectively to the IADE student entirely through the Internet medium, or by including supplementary materials such as CDs or course packs. The challenge in teaching these courses effectively is to provide complete, clear and coherent representations of the different levels of abstraction required, along with as much interaction as possible. [2,3,6,7]

A junior level microelectronics course entitled Active Networks I was taught as an IADE offering for the Electrical emphasis in the Engineering Technology (ET) Department at the University of North Carolina at Charlotte (UNC Charlotte) for the first time in the Fall 2002 semester. In the Active Networks series (Active Networks I and II), course requirements involve the modeling of microelectronic devices and circuits based on physical and operational properties and the use of these models in the design and analysis of systems using these devices. These courses encompass physics, solid-state concepts and conventional transistor circuits and systems.

A variety of synchronous and asynchronous delivery methods, chosen to provide support and enable students to comprehend and appreciate this crucial component in the study of electrical engineering technology, were employed in the Active Networks I course.[2,3,6,7] Asynchronous material was made available through WebCT in the form of a detailed course syllabus, an extensive course schedule with links to individual assignment write-ups, lecture notes, examples, homework solutions, test solutions, and computer simulations.[8] Synchronous delivery was achieved through Centra in the form of office hours, problems sessions and electronic Supplemental Instruction (eSI) sessions.[9,10]

Regardless of the discipline involved and indeed, regardless of whether the course is taught in an on-campus setting or as an IADE offering, the ultimate value is determined by the pedagogical strategies employed in information delivery and the willingness of the instructor and aides (if any are available) to encourage effective communication.[2,3,4,5,11] The remainder of this discussion provides an overview of the tools and strategies employed in presenting the first IADE offering of Active Networks I at UNC Charlotte. For purposes of clarity, the specific software tools utilized will be examined individually in the following sections.

WebCT

In an attempt to minimize potential problems, the Active Networks I course was developed using several compatible delivery and interaction strategies that were intended to provide optimum support for students. The IADE offerings of the ET Department had previously been defined as an asynchronous program and, in 2001, WebCT was chosen by the University as the primary course delivery mechanism. Asynchronous delivery of lecture material, examples, homework problems, projects, self-tests and other course requirements were therefore provided exclusively through the WebCT interface. Lecture material, examples and self-tests were available to the student throughout the semester; however, homework and test solutions were available only after deadlines defined on the individual write-ups or the course schedule. An additional tactic that proved helpful was the creation of an extensive collection of links, categorized by function, in the main WebCT course page. These links provided sources that students could pursue for further information on background material and skills, course topics and PSpice simulation tools, as well as general and discipline-specific research and writing resources. This offering was continuously updated throughout the semester, and sources of information were actively solicited (and received) from class members.

A conscious decision was made to keep this class as informal as possible. Rather than simply repeat the text verbatim, written material was presented in more of a casual, discussion format. Also, since many students still have dial-up internet connections, materials were presented in a simple text and graphic format. However, concepts were illustrated, and problem areas clarified, through liberal use of color and annotations to reproductions of the text's figures. In many cases, a single illustration in the text was turned into multiple graphics that developed the representation of a final text figure, an alternative representation was provided, and/or a derivation was "talked-through" and tied into the text material to illustrate the topic or concept under discussion. The semester material was broken up into several sections defined as Introductory Physics and Chemistry, Diodes, Bipolar Junction Transistor (BJT), BJT Amplifiers, and Operational Amplifiers. Each section of study had an *Introductory Goals and Objectives* segment, the body of material to be covered presented in topical subsections, and a summary of concepts or skills that should have been mastered. Extensive examples were presented throughout, homework was assigned to reinforce key concepts, online quizzes were developed to assist in homework solution, and a self-test (with solutions) was offered at the end of each section.

A comprehensive course schedule provided information as to weekly course topics and links to assignments, as well as providing a location for announcements. Each homework assignment had an individual write-up that detailed content (i.e., WebCT quiz, homework problem(s) and/or PSpice simulation(s)) with specific instructions as to expectations and requirements. Online quizzes throughout the semester were associated with specific homework assignments and were intended to provide a "sanity-check," or hints to common areas of difficulty in understanding of strategies and concepts. Since the quizzes were implemented in WebCT, the student received immediate feedback upon submission that included detailed explanatory notes for any incorrect responses. Homework and test solutions were automatically released after the appropriate submission deadline through the capability of WebCT to allow the designer to define release

criteria. This capability also facilitates a form of immediate feedback that allows students to determine areas of misunderstanding or potential concern.

Each student was provided with a dedicated personal space on the WebCT server that only the student, instructor, and eSI (electronic Supplemental Instruction) leader had access to. Within this space, the student had complete control over content and file management, with the uploaded files date and time stamped. The instructor and eSI leader had access to all student space to retrieve and grade assignments, run simulations, or provide individual feedback. This strategy removed the problems associated with assignment submission through regular U.S. mail, by fax, or as email attachments; i.e., it was instantaneous (or however long it took to upload the file(s)), it was free, it could be performed anywhere internet access was available, the student had complete control until the last minute before the deadline, and successful submission could be verified immediately. Each student also had an archived copy of all materials – both for documentation purposes and, potentially, in the creation of an e-portfolio.

In addition to homework, quizzes, and three proctored semester tests, a final design project and technical report was assigned during the last three weeks of the semester. The design project was defined in such a manner that a comprehensive understanding of the semester's material was required. In addition, project specifications were such that it was virtually impossible to receive duplicate submissions. A comprehensive technical report was also required as part of the final submission, with detailed *Report Guidelines* provided online. The Writing Resource Center at UNC Charlotte was made available to students for assistance in writing the report, which was required to be in the form appropriate for submission to a refereed technical journal. All design materials, simulations, and final documents were submitted directly through WebCT.

Additional presentation mechanisms available in WebCT and utilized in this course included:

- The course calendar in WebCT. In conjunction with the course schedule, a calendar was created to provide comprehensive information as to assignment availability, homework and/or project due dates, test dates, Centra sessions, and relevant announcements. The complete calendar information was provided at the beginning of the semester so that each student would be able familiarize him/herself with the course requirements and would be able to develop a well-defined study plan based on the calendar information.
- The discussion board in WebCT. This format proved to be an excellent resource for communication between students enrolled in this course, as well as with the instructor and eSI leader. Discussions could be private or public, and the only constraint was that all postings must maintain a respectful, professional tone. Students were strongly encouraged to use the public board when posing a question or discussing an area of concern. This seemed to serve to lessen the isolation factor, as others would expand the thread with ideas, hints, or potential resources. The instructor and eSI leader actively monitored the discussion board to ensure relevant and appropriate postings.
- The WebCT email tool. This means of asynchronous communication was the most common, probably due to the familiarity with email communication. Again, WebCT email was regularly retrieved and responses generated by the course instructor and/or the eSI leader.

Centra

In addition to the extensive capabilities provided by WebCT, Centra was utilized to provide a more conventional (and comfortable) interaction between the instructor and/or eSI leader and the students enrolled in the course. Three Centra sessions were offered each week, one each in the morning, afternoon and evening to provide maximum opportunity for attendance. The main advantage of Centra, in addition to the "live" session format, is the ability to share applications between the session leader and the session participants. It is not mandatory that everyone in the session has the application being shared on his or her personal computer, and the leader may grant control to participant(s) to interact with the application being shared. For example, the leader may use the whiteboard to draw a transistor circuit and then pass control to a student to draw the small signal model and solve the problem, or control may be granted to a student to share an application on his or her computer. Application sharing allows others to simultaneously participate in the solution, as well as asking questions about conceptual or mathematical difficulties. This method of interaction proved very useful in terms of clarifying misunderstandings, working through problems as a group, and troubleshooting PSpice simulations. The capacity to record Centra sessions for playback at a later time, for any student who was unable to attend a live session or who may wish further review, was also perceived as a distinct advantage by course participants.

In a companion paper to this work, the eSI leader for this course presents Supplemental Instruction strategies developed to enhance the experience for IADE students, as well as the creation of tutorials using Centra.[10] These tutorials were created using a traditional lecture-style format and contained content that was requested and/or that the instructor and eSI leader agreed to be conceptually difficult. Centra sessions may also be downloaded and archived in a format compatible with standard media players. This allows the archiving and distribution of tutorials or particularly relevant live sessions through links on the WebCT site, downloads, or CDs.

Lessons Learned

We have found that the more interactive we can make the material – in terms of "sanity checks," tutorials, application sharing, and extensive, detailed graphics, the clearer the material becomes to the students who participate in the course. Students in the DE program in the ET Department at UNC Charlotte are generally non-traditional, independent study, remote access, and have full time employment as well as significant family obligations. This generic student profile has proven to be beneficial in the sense that most of the students are mature and highly motivated individuals who recognize the value of education and are willing to make sacrifices. On the other hand, it is a delicate balancing act for many students to accommodate the demands of family, work, and school. In spite of these obstacles, distance education has been proven to be a valuable tool that allows students, who would not otherwise be able to avail themselves of the opportunity, to attend classes and receive an accredited degree. It is however, fundamentally important that a course designer and/or instructor recognize potential problems and provide as much (reasonable) flexibility as possible.

Strategies employed in this course, such as the creation of personal space, extensive details in assignment write-ups, providing immediate reinforcement and information in the forms of online quizzes, homework solutions and test solutions, diligent monitoring of email and discussion boards by the instructor and eSI leader, multiple offerings of Centra sessions, and the recording live Centra sessions and tutorials, were extremely well received by students enrolled in the course. According to an informal course improvement survey at the end of the semester (presented through WebCT and received anonymously), students were unanimous in their approval of the approach taken in developing the WebCT content and the inclusion of Centra into the course. Students also commented as to how comfortable the environment was with respect to asking questions and expressing concerns. This led to several valuable suggestions being received that will be implemented in future offerings of Active Networks I and that are currently being implemented in the follow-on course, Active Networks II.

Future Work

Several areas intended to make future offerings of this course more interesting and effective include, but are certainly not limited to:

- Providing students with a CD with archived tutorials and past tests prior to the beginning of the semester.
- Expanding the use of Centra, possibly in conjunction with related courses offered during the same semester and/or on-campus offerings of the course of interest.
- Exploring the incorporation of animation to enhance lecture materials, enforce key concepts and provide additional methods of interaction.

Informal course surveys will be presented through WebCT as a continuous improvement mechanism. Finally, impressions, comments and advice are actively solicited from current and former students, faculty, and members of the student learning and development support infrastructure.

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