Paper 16:

A learning, assessing, and evaluating environment for asynchronous Web-based courses

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Abstract

- A methodology for web-based learning in engineering has been developed and offers an environment for educators to deliver hypermedia information in a controlled and structured way. The appropriate design of this environment was of paramount importance so that the student could navigate it in a simple and efficient manner. The system provides feedback to the student for learning assessment and feedback to the instructor and curriculum originator for course improvement. This environment has been utilized over 4 semesters to support the learning in a digital logic design laboratory. It has provided essential and supplementary material including animations, video, simulation, as well as text and graphic information.

Methods and Approaches

1. Introduction

- At the University of Connecticut's Computer Science and Engineering Department, World Wide Web-based laboratory assignments have been developed for the sophomore-level digital design course. These assignments include all of the materials and tools available to students in a traditional laboratory setting, but are accessible from any computer with access to the Web. In order to create such laboratory assignments in a controlled and structured way, a methodology has been developed for web-based learning. This methodology, while it has been applied to laboratory assignments specific to digital logic design thus far, appears to be general enough to be applied to other areas in computer science, as well as other engineering disciplines and perhaps even disciplines outside of the engineering domain. The following discussion of the web environment will provide guidance to those who are interested in developing comprehensive web-based laboratory assignments.

2. Goals & Objectives

- Several goals and objectives were defined prior to the development and implementation of the web-based learning environment. One important goal was to strengthen the content of our laboratory assignments by adding breadth as well as depth into the traditional digital design assignments contained in the course curriculum. Through the use of interactive web programming, outside web links, and various state-of-the-art web-based multimedia tools, this goal was achieved.

  For example, a laboratory assignment based on a microwave oven in which the students are required to design and implement (through a software simulation package resident on the client machine) a microwave oven control panel has been developed. This particular laboratory assignment has been enhanced in several ways. Firstly, manufacturing concepts have been incorporated into the design specifications of the controller to introduce issues regarding manufacturing tradeoffs. These specifications include limitations on the size and cost of the controller, as well as limitations on the power consumption and speed at which the controller must operate.

  When the students complete their design, they are required to enter, into a web- based form, the number and types of chips used in their final implementation. The form, through the use of Java Script, provides immediate feedback to the student as to whether the design meets the cost, speed, and power consumption requirements. If the defined specifications are not met, students must redesign their circuits. Secondly, additional manufacturing information is available to the student through the use of outside links to the U.S. Government's web site containing the Code of Federal Regulations, and the Federal Drug Administration. Lastly, breadth has been added through the creation of various animations and video clips which show how a microwave oven cooks food, and which demonstrate the route that the microwaves take from their generation in the magnetron to the dispersal in the oven cavity.

  Another important goal in developing web-based laboratory was to involve faculty, graduate students and undergraduate students in the development and implementation processes. A horizontal and vertical structure has been formed for the development team. The horizontal structure is composed of the faculty and graduate students on the project whereas the vertical structure is composed of undergraduate students who work under the advisement of the faculty and graduate students. The horizontal structure also included faculty from the state's Community Technical Colleges who have articulation agreements with the University and who provide a stream of transfer students. This experience of multi-level involvement has proved rewarding for both graduate and undergraduate students as the graduate students gain valuable experience in advisement, preparing them for potential academic positions, while the undergraduate students are excited to work with faculty and graduate students. At the same time, the undergraduates gain additional experience for potential employment opportunities.

  Additional goals in the development of the web-based learning assignments include maintaining a consistent interface layout for student familiarity, providing a mechanism for immediate laboratory

feedback and evaluation, developing a technique to continuously update the context sensitive help utility, and utilizing a method of presentation to ensure ease of dissemination. Each of these objectives are met in the design and implementation of the learning interface and modules and are discussed in the next section.

3. Web-Based Learning Features

- The goals and objectives discussed above have led to a methodology that defines several unique web-based learning features. These features include, exploiting the freedoms of learning, the development of a multi-framed interface design, access to various communication tools, a context sensitive help facility, electronic submission of laboratory feedback and evaluation, structured students self-tests, access to multimedia teaching aids including animation and video, and multi-lingual capabilities. Each feature is discussed below.

3.1 Freedoms of Learning

The creation of the laboratory assignments is based on the underlying methodology as a way of providing the students with greater freedoms of learning. [We declare these as the Learner's Bill of Rights.] The very nature of the web ensures Freedom of Time and Place since the information is available 7 days a week, 24 hours a day. Students can work on assignments when and where it is convenient for them - be it the lab, the dorm, or at home. It is no longer necessary to balance the hours and locations of the laboratories against classes, meals and extracurricular activities.

The Freedom of Learning Style also suggests that students can work at a pace at which they feel most comfortable. They can review supporting material - lecture notes, video clips, references, etc. - as often as necessary. The fact that these materials are available at the time that the student is attempting the assignment helps to reinforce both the methodology and the reasoning behind the work.

The Freedom of Access to the Instructor is accomplished through the use of context- sensitive help and interactive question and answer sessions which are used to build student profiles. This allows students to have an "instructor" available whose attention is devoted exclusively to them and who adjust to their needs. When the prepared materials are not sufficient, the student has help available through e-mail and course-specific discussion groups. The goal in developing the methodology is to free students from external constraints on learning, and to provide an environment where students can learn wherever, whenever, in whatever style is right for them, and receive personalized feedback on their achievements.

3.2 Interface Design

The interface, as shown in Figure 1, is a screen structure composed of four distinct frames formatted by a web browser such as Netscape Navigator 3.0 (or higher). The top frame is a heading identifying the source of the assignment and containing graphical links to the home pages of the University of Connecticut, the Computer Science & Engineering Department and CSE208W, the Digital Logic Design course. The left-hand frame contains an index of the material in the module and provides links directly to the pages which are targeted to the content frame - the largest one in the window. The content frame is the area in which the assignment is delivered. The bottom frame contains a number of buttons including those for help, e-mail and credits, each of which are discussed below.

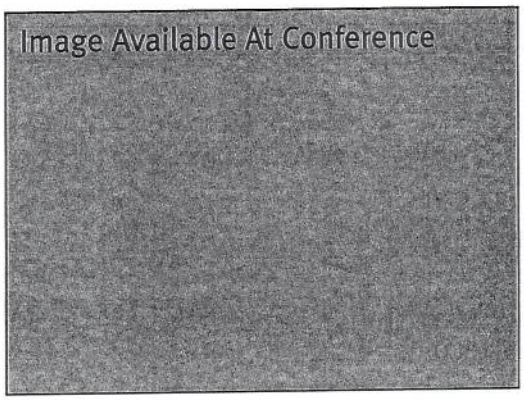

Figure 1

The index of material in the left-most window has a strongly structured format. The main headings of the index classify elements of the lab into distinct categories, namely Notes, Assignment, Feedback, Multimedia Aids, and Material. The notes links provide a description of the lab's goals and objectives for both the student and instructor. The assignment heading divides the assignment into sections which include: prerequisites, objectives, background, theory, procedure, testing, deliverables, and references. The feedback links provide information for the students through the student self-tests, and for the developers through the electronically submitted lab evaluation forms provided by the students. The multimedia aids category provides students with links to various computer animations, sound bites, and video clips. The materials section provides links to any additional material such as software applications or hardware kits needed to complete the lab assignments.

It should be noted that all of the laboratory assignments are created using the same multi-framed window layout and index structure. This environment is intentionally consistent throughout the entire course so that students can become familiar with the format.

3.3 Communication Tools

Students are provided with various tools for communication in which they can contact fellow classmates, teaching assistants, laboratory originators or the instructor. The lower frame in the multi-framed window contains several buttons through which these tools can be accessed. One communication tool provides direct access to e-mail. This simple facility enables students to contact the instructor, teaching assistants or the authors of the lab module directly. Addresses of the individuals are provided automatically through the use of hypermedia link to Netscape Navigator's mail facility.

3.4 Context Sensitive, Self-Seeding Help

The defined methodology also provides a complex help facility which can be requested at any time by the student using the help button in the bottom frame of the window. The help provided is context sensitive in that a specific help screen is displayed depending on the particular information displayed in the content frame.

The initial set of help files for a particular laboratory assignment are first created by the development team who attempt to anticipate the type of help students would look for. The second phase of help is provided by the students themselves. If the students are looking for help in a particular area and their question is not answered by the help facility, then the students are asked to submit a short electronic form describing the type of help they were looking for. The authors can then respond with additional context-sensitive material for subsequent students. This completes one of the learning feedback loops.

3.5 Laboratory Evaluation

Another important feedback loop in the defined methodology is the laboratory module evaluation by the student. This step is critical to provide improvement and response to the learner's needs. The learning environment is equipped with a facility for the student to provide immediate, electronically submitted feedback to evaluate the lab assignment. In order to obtain honest feedback, an option of anonymity is available for the student. Once the electronic forms have been submitted, the instructor can immediately acquire composite results from the student responses and make adjustment to the assignment as necessary. Recent results indicate a 80+ percentage acceptance of the assignment having met the objectives.

3.6 Student Self-Tests

Questions related to the module content are available for student self-assessment. The results of the assignment are also available to the instructor. They are structured to align with the levels of Bloom's Taxonomy [1] and enable feedback to be given that provides a profile of the student's learning from cognition to evaluation. These data allow individual student-based assessment to take place as well as a class matrix to be produced that provides the instructor with general information regarding overall class achievements.

3.7 Multimedia Aids

A variety of multimedia aids are incorporated directly into the web-based laboratory assignments. These aids include video animation, numerous graphics, and various sound clips. Through the use of Netscape's current web technology all of these aids are incorporated directly into the browser and require no additional helper applications. Short video clips that have been created are available for several of the web-based laboratory assignments in the course curriculum. Some of the video clips are enhanced using sophisticated software to add sound and annotate text and graphics. One of the concerns is that the more sophisticated the video becomes, the larger the file size and the longer the download time. Because of this constraint, video clips have been kept very short and used conservatively. Experiments with video streaming will be completed soon.

Computer animation can be a valuable visualization tool because complex material can be presented in such a way that students can grasp difficult concepts more readily. One of the more popular software packages currently used to create animations is Macromedia's Director application. Using Director and some post-processing shareware packages, it is now possible to develop animations that run directly inside the Netscape browser. This powerful package requires a good deal of overhead time to become proficient. Further developments are to be executed using Authorware.

Multi-lingual sound capabilities have also been incorporated into a select number of laboratory assignments. Sound clips summarizing various laboratory objectives are translated into German, Spanish and Mandarin Chinese.

3.8 Ease of Dissemination

One of the major goals in developing the various laboratory assignments was to ensure ease of dissemination. It was very important that our developments could easily be distributed to the University of Connecticut's branch campuses, the local technical colleges with whom the University have articulation agreements, and to other colleges and universities. The very nature of the World Wide Web has ensured that this objective has been met.

4. Challenges

- The design and implementation of the laboratory assignments based on the methodology for web-based learning has proved challenging. The development process required that major selection decisions were made on a technology that was on the cutting edge. For example, at the time that the frame layout and interface design was being defined, Netscape had just announced the support of frames and Java Script in the upcoming version of their web browser. Often times during the development process, there was concern over whether the system was crashing because of the development endeavors or because of a beta version of Netscape's web browser that was being used.

  Perhaps the biggest challenge has been that of development time and learning overhead. While the development time has been somewhat streamlined from our original struggles, a significant effort must still be applied to produce comprehensive laboratory assignments. New development tools, including the use of Authorware, should aid in reducing the time of the overall development process.

5. Future Outlook

- The laboratory assignments that have been developed at the University of Connecticut are in a constant state of evolution. The insightful feedback from our students and peers is continually incorporated into all of our web-based laboratory assignments. At the same time that success seems to be present, the design team is looking ahead to future developments. Some of these include widening the evaluation scope to other colleges and universities, incorporating Java into the implementation process, providing more opportunities for evaluation,and testing the application of the methodology outside the engineering discipline. The development of work conducted to date has provided an encouraging impression of its value in an

undergraduate engineering learning environment, yet further research and development is necessary to use the constantly evolving web-based multimedia tools to their full potential.

References

1. Bloom, Benjamin, Taxonomy of Educational Objectives, Longman's & Green Publishing, New York, 1964.