

Articles

Flexible Learning Via Web-Based Virtual Teaching and Virtual Laboratory Systems

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Virtual Teaching System

In the current economic situation, most academic institutions would like to plan new courses to increase enrollment. Often, these changes do not follow with a proportional increase in cost or staff numbers to the institution. For cost-efficiency reasons, a reduction in student contact hours is most desirable, providing that this can maintain the quality of the learning experience. Web-based teaching is a possible and economical solution to this problem (Lee, 1999).

To implement Web-based teaching, the Department of Engineering of Hong Kong Institute of Vocational Education (Tsing Yi) set up an interactive virtual teaching system for the subject Logic System for students studying sub-degree engineering courses. Students are able to obtain updated teaching notes, tutorials, and digital video instructions through the Internet and displayed on a Web browser. Those Web-based programs will automatically correct students' answers for quizzes, and lecturers can obtain and monitor the students' feedback directly without any delay. The aim of the cur-

rent design is to provide a more attractive and interactive environment for students to learn.

The content of this virtual teaching package includes the following parts:

- Background information—Students can learn or review the fundamental concepts in this background section. The Web site also provides related materials such as aim and objectives, the syllabus, and booklists.
- Multimedia lecture on the Web (see Figure 1)—This section provide a place for downloading conventional lecture notes (in both Acrobat and PowerPoint formats) or viewing short video clips for better understanding of each topic. This multimedia approach attracts attention, generates interest to learn, and facilitates students' understanding. Students will be able to apply the theory learned to finish the assigned tutorials. To evaluate what the students have learned from the content, this section includes automatically marked short quizzes. Students must answer correctly a certain percentage of questions at the end of a chapter before moving on to the next chapter.
- Online discussion and related links—In order

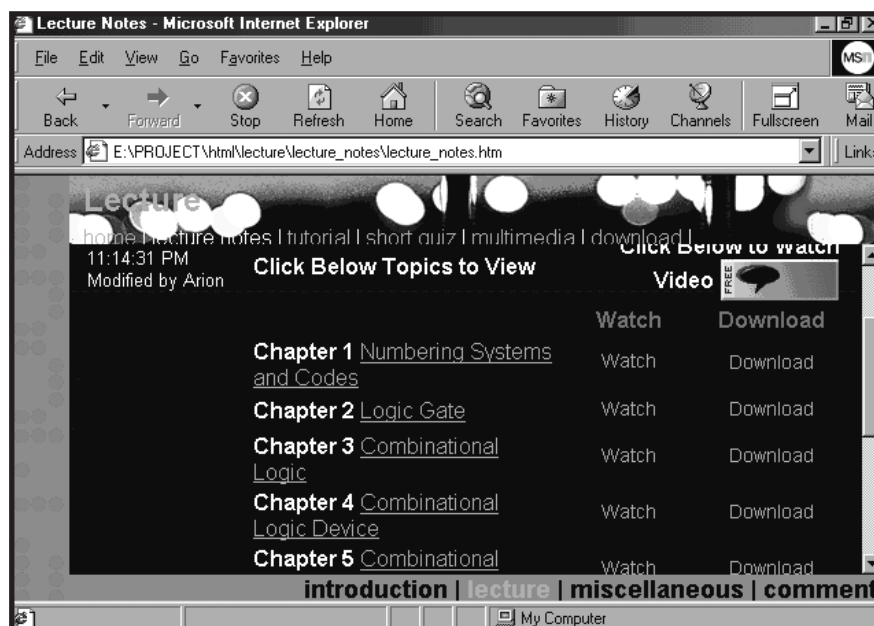
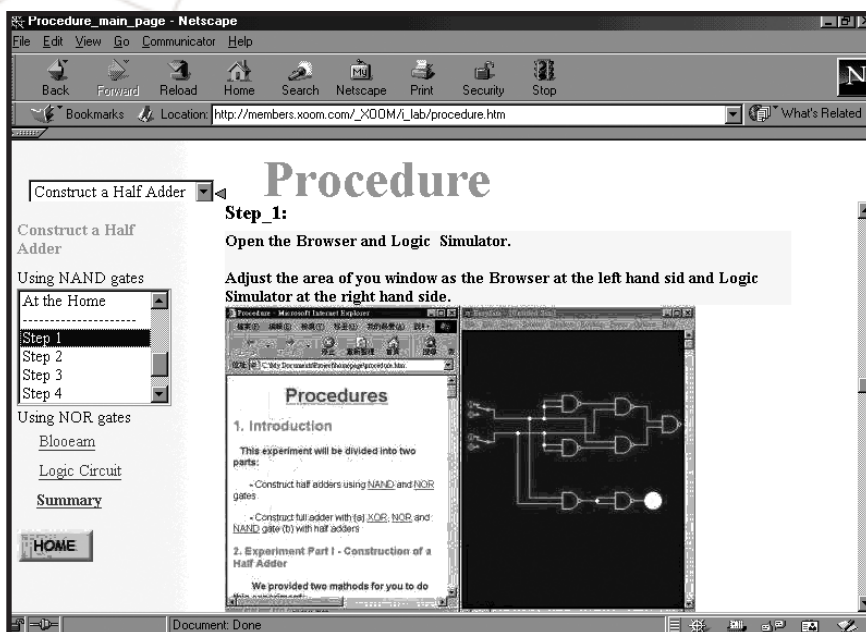


Figure 1 Multimedia lecture notes and explanation

Fig 2 Procedure for the virtual laboratory



to simulate the classroom environment, this section provides an online chat room to allow discussion through the Web. Other functions in this section include Web linkage to IC manufacturers, downloading useful data sheets, links to other online lecture or tutorial sites, a search engine, and a glossary for detailed explanation for a particular term. These functions help students to obtain more theoretical and practical knowledge.

- Comment and guest book—Students can submit questions and suggestions to the Webmaster through the easy e-mail system. They can leave or view comments on the guest book provided in this section. Such feedback can provide for further improvement for this Web-based teaching system.

Virtual Laboratory System

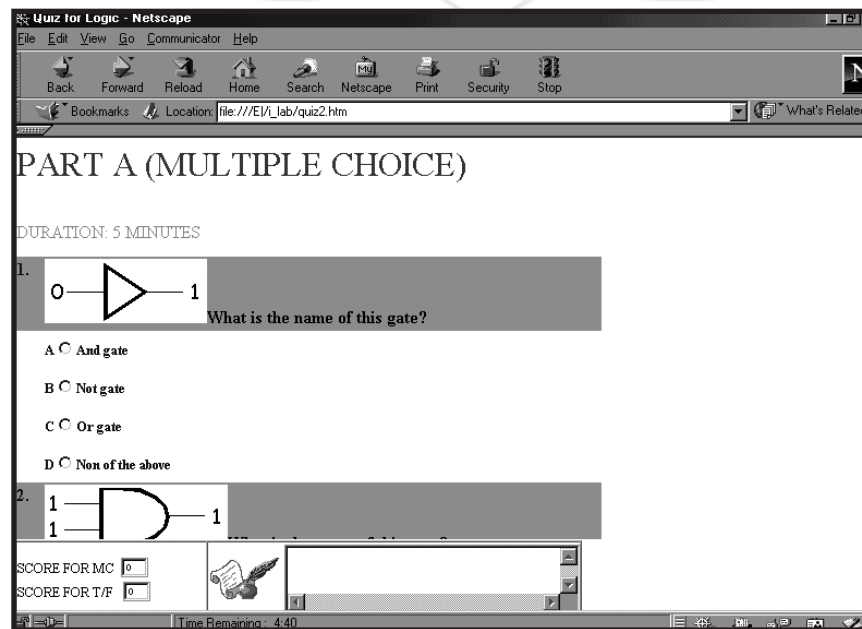
The laboratory is a very important part in engineering education. In fact, heavy weighting in practical training dominates technical education (Leung, 1999). On the other hand, students must also understand a variety of rules, theorems, and devices that involve primarily knowledge-based learning. It is then the educator's job to let students learn to practically apply that knowledge through problem solving and design exercise (Ericksen & Kim, 1998). The virtual

laboratory is particularly useful when an experiment involves equipment that may be harmful to human beings. The laser virtual laboratory developed by the Physics Department of Dalhousie University (Paton, 1999) shows how to operate a real time dangerous laser laboratory with the help of commanding equipment through the Internet.

The Department of Engineering of Hong Kong Institute of Vocational Education set up another virtual laboratory system for the same subject, Logic System, for the same group of students. The design of this virtual laboratory involves simultaneous use of the Web browser and any application package. Students are no longer limited to information provided by the prepared laboratory manual. Students can either conduct simple electronic experiments in the computer center on campus or stay at home to do experiments through their computers via the Internet. Students submit answers and comments for the laboratory through the Web. Lecturers can monitor the results of each student and immediately help students with problems. The current content of the virtual laboratory includes the following parts:

- Background information—This section contains all necessary basic concepts and theo-

Fig 3 Quiz section



rems to perform experiments in the virtual laboratory. Students can save a lot of time finding necessary background information (e.g., theories of logic operation and simplification) to support their use of the virtual laboratory in different locations. They can easily review the basic knowledge learned in the class before going to the procedure section of the virtual laboratory or they can refer back to this section if they find something that is not clear.

- Multimedia explanation and demonstration—This section helps students understand the basic concept of the virtual laboratory by providing different video and audio aids that demonstrate the construction and running steps in the simulation environment.
- Download section for lab sheet, data sheet, and shareware simulator—Students can download lab sheets in this section and then follow the procedures in the lab sheets to perform the virtual experiment. The download area also provides students a location to obtain necessary utility programs (e.g., Adobe Acrobat) and simulation software (e.g., EasySim, MMlogic). All of these software programs are freeware or shareware.
- Step-by-step laboratory procedures—This section includes several experiments for students to perform via the Internet. Step-by-step descrip-

tions, screen captures of simulation software (see Figure 2), and multimedia demonstrations provided in the multimedia section help students with less hands-on experience.

- Summary report and interactive quiz—This section consists of two parts. The first part is a lab report where students answer some questions related to the virtual lab, which provides a chance for them to write a summary report. Lecturers receive the summary report via e-mail. This arrangement provides immediate feedback to lecturers and a means to assess the performance of students participating in the virtual laboratory. The second part includes a quiz section with multiple choice (see Figure 3) and true or false type questions. These two quizzes allow students to review what they have learned in the laboratory. After completing the two quizzes, the screen displays the analysis of the quiz results. This analysis provides feedback to both students and lecturers.
- Online comment and feedback statistic—Students can offer their opinion for improving the virtual laboratory by selecting corresponding items (from excellent to bad) in the questionnaire. They can also leave messages on the guest book. Students and lecturers can easily check the questionnaire results (shown in bar chart) or take a look at the comments on the guest book.

Table 1 Feedback From Students Using Virtual Teaching and Virtual Laboratory

Feedback	Virtual Teaching	Virtual Laboratory
Encouraged to participate	78%	82%
Motivated to learn	74%	92%
Software interacted well	83%	78%

Students' Reaction

Eighty first-year engineering students at the Hong Kong Institute of Vocational Education tried the Web-based teaching and laboratory systems separately in a computer laboratory. In order to assess students' views of this Web-based approach, students completed a set of questionnaires immediately after their first experience of these systems in the computer laboratory. In addition, students freely wrote down their feedback to this study at the end of the questionnaire. The questionnaire's main purpose was to obtain students' views in regard to existing functions of the system, learning to use the virtual systems, quiz arrangements, and user interface, and to investigate the needs of students in the virtual environment. Finally, in order to find out how this virtual system approach might affect student learning and to obtain their views towards this new teaching approach, the lecturer randomly selected 8 students from this group of 80 students and interviewed them using open-ended questions.

According to the results of the questionnaire, most students showed a positive attitude towards the virtual systems and found that such systems encouraged and motivated them to learn better. Most students found it interesting to learn through virtual teaching (VT; 89%) and performing experiments through virtual laboratory (VL; 88%). Some students related their interest in using VT or VL to their previous knowledge of Web browsing.

"I do not feel so interested as I am not familiar with browsing through the Web."

"I am not so familiar with the computer. So, I prefer to do experiments in a normal laboratory class"

On the other hand, other students who had suffered from previous hardware building experience found that VL was very useful for them to learn through this Web-based experiment.

"I feel that it is more convenient in performing the lab in this way. I do not need to find real electronic components in order to do the lab. I need not worry about loose connections of wires."

"It does not require me to set up equipment. I can know the results by pressing a button on the screen. I also know whether my design is working or not without constructing the circuit by real components."

Nowadays, a common phenomenon is that students have difficulty in learning and spend less time in studying. However, 60% and 67% of the students felt that it was easier to learn difficult concepts through VT and VL, respectively. The reason was that students found most information in the Web-based system or easily searched in the browser environment.

"It is easier to learn as these systems can contain hyperlinks to connect to a site so that we can get information that we need. We can also search information using the Web browser in the same environment. We can learn faster in this way."

Students were more active in learning in a Web-based environment than in a conventional laboratory class. These Web-based systems

encouraged most students (see Table 1) to participate during the process of using VT or VL and students claimed that they were motivated to learn the subject. Actually, students found that the software interacted well with them during the learning process. Moreover, students could review the VT or conduct the experiment again at any time by means of VL.

In the assessment part of these Web-based systems, 80% and 73% of students agreed that the quiz in VT and VL, respectively, could test how much they gained in the experiment. Also, 70% and 77% of students found that the quiz in VT and VL, respectively, could improve their understanding of the topic. Some students found that it was interesting to do the quiz.

“The quiz is interesting and provides us another channel to understand the content more.”

In the response to other questions for investigating the needs of students in the environment of Web-based systems, most students (90% for VT and 82% for VL) liked immediate feedback after finishing the quiz. This finding helped the developer of these Web-based systems to prioritize marking and giving feedback.

Also, students (>90%) reported the content should be more interactive. Video-conferencing, e-mail, and discussion groups can fulfill this requirement. Otherwise, students would find it boring if they just read materials provided in these Web-based systems.

“I find that it is more attractive, interesting, and easier to understand by using multimedia.”

“I like the video or movie more. I like to group information and select to read by pressing a button on the screen rather asking me to read many texts. Texts are boring.”

However, only a small percentage of students agreed that VT (35%) or VL (52%) could replace the normal class or practical laboratory.

Reflections on the Systems

The developer built these interactive virtual teaching and laboratory systems, and the subdegree engineering students who used the systems provided valuable feedback. Actually, these

nonstop systems can provide a multimedia learning environment to motivate students, promote a more active form of learning, offer more individualized and independent learning, and provide simulations of complex scientific processes that are less likely to be demonstrated in a normal class or laboratory.

The feedback from students confirms that they like this innovative learning and working environment and feel encouraged to learn better in this way. The fact that students do not have real face-to-face learning and hands-on experience with the senses are the drawbacks of these Web-based teaching systems. Actually, VT or VL is not going to replace normal teaching or workshops. They can provide a complement to traditional classroom and laboratory resources (Chin, 1999; Chu, 1999; Lee, 1999). Through longer exposure, different assessment tasks, evaluation, and modification, the developer can improve the materials of VT and VL through these nonstop cycles of design, trial run, feedback, and modification.

The Future

There is the trend for tertiary institutes to increase student enrollment but without adding any staff. In order to overcome this increasing student-staff ratio and maintain the teaching and learning quality, universities or colleges could implement Web-based teaching and laboratory systems to reduce the workload of teaching staff and improve the learning outcome of the students. Future developments of these systems include:

- Integrating the virtual teaching and virtual laboratory (Waite & Simpson, 1996) to benefit students by presenting the same material in different ways and to exercise different learning styles. Our department is planning to build a scenario-based learning package (Chu & Leung, 2000) that will simulate a scenario similar to the students' future working environment. Students can virtually walk around and realize how the actual working environment should be. They can also take this opportunity to study how to operate and interconnect different equipment. Students can use this virtual environment to better understand the operation and the theory behind the operation. Using hierarchical explanations can also suit the

learning progress of students with different backgrounds. This scenario-based learning package will enable students to virtually immerse themselves in a scenario to enhance their learning and practical knowledge.

- Improving visual impact and reality of the existing VL system by real time captures the image and controls the instrument in the laboratory. Using virtual instrument control software such as LabVIEW (Ko et al., 2000), it is very easy to implement a real time remote laboratory system. In such a design, a more realistic feeling of controlling the

remote instruments is accomplished by using a mouse to press control buttons or to turn knobs displayed on the screen. Users can observe any change of output from the real-time image sent from the remote site through the Internet.

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