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The Benefit of Virtual Teaching to Engineering Education*

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Recent advances in web technology have transformed the World-Wide-Web from delivering static text to providing an easily accessible multimedia channel for dynamic, interactive communication. It has become a commercial possibility to combine text, graphics, sound, video, and animation in our teaching systems. More people will use multimedia for teaching, learning and playing through the Internet. In this study, we describe the system we are developing. We are going to evaluate the effectiveness of various approaches to using the Web for student learning and to find out what web learning methods the students like most. Satisfactory results were obtained through questionnaire and feedback.

INTRODUCTION

TODAY the World-Wide-Web has been enthusiastically welcomed by large sections of our society [10]. Initially an academic curiosity to the majority, the Internet has appeared in many unexpected places. Using the Web as a teaching medium is an exciting prospect that promises to make remote learning easier, more interactive and more convenient [1]. Learners can then schedule their time and progress of learning according to their own style [1].

Bender [11] showed the potential power of web-based learning that can be gained by merging techniques from knowledge and hypermedia systems to alleviate problems such as: lack of control and initiative, difficulties in understanding the reasoning process, absence of overview and problems in comprehending the complexity of the domain. In addition, Nott [12] found the advantages of the WWW for science teaching which included: multiplatform access, non-reliance on specified classrooms with consequent saving in teaching space, off-campus delivery, hypertext facilities with structure guidance, ability to offer students choice of resources and student feedback using 'fill-out forms'. Byrnes [13] also succeeded in using an Assignment Management System to enable distance learning students to receive assignment specifications as well as to submit completed assignments in many formats and receive marked, annotated assignments from their home personal computer or from the campus network.

Although learning through hypermedia has many advantages, navigation in hypermedia systems can also cause confusion and disorientation [2–5, 8] because users often have frameworks for organising information that are different from that of the systems. To avoid this disorientation, navigation structures in on-line systems must be apparent to the user [5, 6, 8].

Several criteria were designed for on-line learning materials to avoid the disorientation mentioned [1, 7, 8]. The site should be appropriately designed for its audience in terms of both reading level and scientific content. It should provide enough background information to help students contextualise the information they found. It should be self-explanatory, in the sense that users could use the sites without assistance. It should foster inquiry-based learning, not giving answers but rather providing scaffolding to help students generate questions and seek information. It should be easily navigable using consistent graphical icons, table of contents, and other organisational tools, placed strategically to help users understand the structure of the site.

Long Web pages require users to remember too much information and cause them to 'lose sense of the context' [9]. Based on Hoffman's observation [1], the learning materials in the Web pages should be modified to create succinct pages with important information clearly in the browser window. This allowed students to obtain relevant information quickly during their investigations.

The objective of this study is to evaluate the effectiveness of various approaches to using the Web for student learning and to find out what web learning methods the students like most. This is an iterative process: we eliminate components that do not work, and strengthen those that do.

THE WEB-BASED LEARNING PACKAGE

We are currently implementing web-based learning packages for many of our subjects including microprocessors, power electronics and

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networking; this study will focus on evaluating a package for first-year full-time engineering students learning programming using the C language. The teaching package consists of the following components:

- Teaching material using animation, images, sound and video to explain topics to the student.
- On-line tutorial questions that the student may answer whenever they want practice. The package provides immediate feedback and links to sources of information that the student may study to be better equipped to answer the question.
- A database-driven tutorial program that allows students to write a C program to solve a particular problem, then try it out. If the program cannot compile, the compiler error messages are translated into a form that the student can more easily understand. If the program they have written compiles, then the system runs it after making many sanity checks on the program, and allows it a limited running time before it is terminated. The output is compared with the requirements. The student receives immediate feedback on their effort. The database holds the tutorial questions and the criteria for success, as well as maximum running time and code size. The student accesses the program from links in the teaching material. A parameter selects the question from the database. The advantage for the student is that this system works even when the student has no C compiler installed on their own computer, is platform independent, and provides more guidance and feedback, and is available for immediate practice as soon as a topic has been introduced.
- On-line quizzes with automatic marking, instant feedback, and automatic mark entry into mark databases.
- Easy e-mail access to each other and to the lecturer.
- Discussion groups for each subject, encouraging the students to interact with each other, and with the lecturer. All assignments and subject announcements appear here. Students are encouraged to use this as a forum to discuss the assignments, and any issues relating to the subject and its administration.
- Chat systems that allow students to interact with each other and with the lecturer before a test to help clarify those misconceptions discovered in the preparation for the test. Part-time students are likely to benefit from this when it is made available to them.

THE CURRENT WEB-BASED SYSTEM

Our current web-based learning system is founded on a consistent metaphor. From the course library, the student selects a bookcase corresponding to their course and year (Fig. 1).

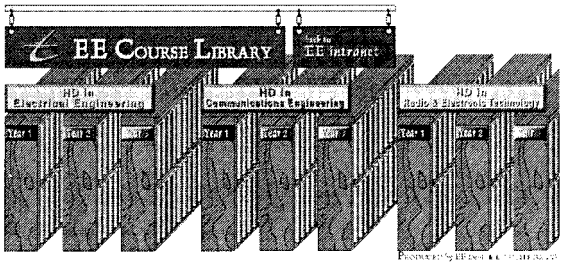

Fig. 1.

From the bookcase, the student selects a book (Fig. 2.). Each book on the top shelf corresponds to a subject, providing services similar to those for the C teaching package. Those on the bottom shelf provide course level services to the student.

Text labels are available for people with slow Internet access to select what they want before the graphic has downloaded.

Some of these services are database applications that provide searchable access to:

- timetables
- exam and continuous assessment marks for the students who has authenticated themselves
- current job information.

Other services include:

- lecture notes and lab sheets in printable PDF format;
- syllabuses;
- course handbooks;
- information about upcoming industrial visits;
- discussion groups and chat systems;
- information about projects;
- an extensive organised selection of data sheets in PDF format.

Limitations

Most of the system is currently available only within the campuses of the VTC of Hong Kong. We expect the system will be available over the Internet by the end of 1999, with the cooperation of the Computer Centre staff. The URL will be http://www.tyee.vtc.edu.hk/.

FEEDBACK

All engineering classes used in this study were taught by the second author and were

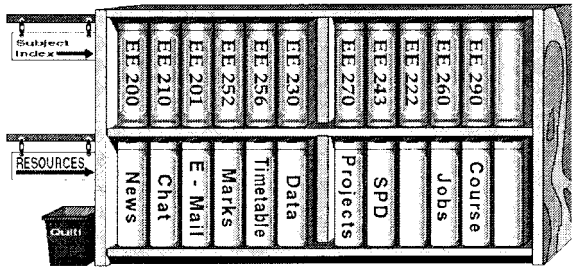

Fig. 2.

supplemented by the Web learning package. Positive response from students in this class was obtained through questionnaires and feedback.

Students

The 81 students who are subjects of the study were year one engineering students in Hong Kong Technical College (Tsing Yi). The four engineering classes used in this study were taught by the same lecturer.

Instruments

In order to assess students' views of this teaching approach, a questionnaire was given to each student after their first experience of virtual teaching in a laboratory. In addition, students can freely give their feedback to this study. The first part of the questionnaire aims mainly to obtain students' views towards existing functions, about learning using virtual teaching, quiz/test arrangements, user interface, and the value of virtual teaching, for example: Can virtual teaching replace normal teaching? The second part of the questionnaire aims to investigate the needs of students in this virtual teaching. Finally, students were asked to make comments on how to improve this system.

RESULTS

The view of students towards this virtual teaching can be obtained through the questionnaire described above. The following summarises the data collected.

First part

The first part of questionnaire includes 14 statements which aims mainly to obtain students' views towards the existing teaching package. Most students show a positive attitude towards this virtual teaching (VT) system and find that such a VT system can help them to learn better. Most of the students (97%) find it interesting to learn through VT.

Also, students appear to be more active in learning in a VT environment than in a normal lecture environment. Most students (90%) are encouraged to participate during the learning process using VT and 78% of students claim that they will be motivated to learn the subject by using VT.

Some students find that they are not easily able to learn some subjects in a normal classroom with only the lecturer's explanation on the white board. However, 62% of students feel that it is easier to learn difficult concepts through VT.

Nowadays, a common phenomenon is that students spend less time in studying but 69% of students will spend more time in studying after using VT. One of the reasons is that the VT system attracts them to stay in front of the computer. Actually, 76% of students find that the software interacted well with them during the learning process using VT.

In the assessment part of this VT system, 87% of students agree that the quiz in VT can test how much they gain in the learning process and 88% of students find that the quiz in VT can improve their understanding of the topic. Finally, 89% of students agree that the test in VT can review how much they learned from the topic taught.

For the existing VT system, 85% of students find the e-mail system included in the VT system helped them to ask questions from the lecturer more easily and 84% of students like the video in this system to explain a topic.

One of the big arguments concerning VT is whether VT can replace normal classroom teaching. In the existing VT system prepared for this study, only 44% of students agree that VT can replace normal teaching in the classroom.

Second part

These questions were mainly used to investigate the needs of students in the environment of virtual teaching. In the response, most students like immediate feedback after finishing the quiz (87%) and after finishing the test (90%). This finding helped the developer of this VT system to prioritise marking and giving feedback.

Also, students do not like to work alone, they like to share ideas with each other. That is the reason why 77% of students want a discussion group provided in the VT system.

92% of students would like more interactive teaching in the content. Video-conferencing, e-mail, on-line compilation, can fulfil such kind of requirement. Also, students would find it boring if they can only read materials provided in the VT system. That is why they like to have more quizzes (75%) and more tests (72%) in the content.

This part of questionnaire also designed to find out which kinds of multimedia students like most. The results are listed in Table 1.

From the percentage listed in the above table, students like all kinds of multimedia to be included in the VT system. The reason of lower percentage of video is due to the fact that the average loading speed of video is slower than the sound and animation.

Overall results show that students like this virtual teaching system and feel encouraged to learn better in this way. Also, students can improve their understanding after this study. However, more than half of them (56%) do not agree that

Table 1.

Students like the kind of multimedia in the content	Percentage
video	82%
sound effect	88%
animation	88%

virtual teaching can replace conventional teaching in the class.

Feedback from students also shows positive responses towards their virtual teaching system.

- 'The idea is good, it is interesting and new for students. Also, it is more attractive than notes.'
- 'VT can improve students interest in learning of programming especially for me.'

Students do not agree that virtual teaching can replace normal classes:

- 'It is helpful for student to find what they don't know. I think the Web page is more suitable to be a supplementary exercise and reference.'

Students also like to add more multimedia components and explanation to this system:

- 'My comment is more sound, video, and animation.'
- 'Adding more movie in the VT system will be better. I like lecturers who are talking about the answer of the questions.'
- 'More explanation of program and quiz are needed.'

FUTURE WORK

Problems to be solved

There is a now major reorganisation of tertiary vocational education underway in Hong Kong. This requires departments from a number of geographically separate campuses to work closely together to teach common year one subjects to large numbers of students. This requires access to common teaching materials, common methods of assessment, and new levels of cooperation between campuses. The methods used to support teaching within one department may not scale well to the new arrangement. Resources are very limited.

Some solutions

We considered various options for supporting our students and staff. We decided to use an object-relational data server together with web servers and web-based applications to provide a scaleable way to meet the needs of our students and staff. We have been working on this for a few months. Our first application gave students their exam results over the Web. The second used an interactive voice response system (IVRS) to provide student results by telephone. The third application is a web-based student personal information system, where information typed in by the students themselves together with enrolment information can be searched in many ways, including by selecting their photograph from those whose information matches a query.

The servers

We have a number of web servers: one on NT, another on Linux (Red Hat 6.1), and a third on Solaris. The object-relational database is PostgreSQL 6.5.2 [19], an open source data server that can scale well under load. Besides good performance, reliability and advanced architecture, other worthwhile advantages include no client license fees.

The applications

We have used three methods for connecting to our data server: ODBC [23], JDBC [24] and DBI [16, 22]. All are DBMS (database management systems) independent interfaces, allowing us to move the databases to other DBMS in the future without re-writing our applications. The ODBC applications were written in Visual C++ on NT. The JDBC applications are Java servlets [20] that communicate with Java applets through the web server. DBI is a Perl module used together with the Apache web server's mod_perl [14, 18] interface. This provides the client-independent advantages of CGI [15] without the performance penalties. The work is done by lecturers with support from final-year Higher Diploma students.

Other web-based projects on our to-do list that use the database include:

- student interview records
- students needing counselling
- continuous assessment record
- exam results
- exam re-sit
- BOE meeting
- timetable
- attendance record
- student professional development (SPD)
- jobs and local industry
- alumni management
- final-year project management
- final exam timetable
- student feedback surveys
- user manual
- operations manual.

Security

Working with private information over the Internet is addressed using SSL encryption together with password authentication. SSL is available free using mod_ssl [21] for the Apache web server. Most web browsers support SSL. Authentication is securely implemented using methods from chapter 6 of [14], available on-line as [17].

Client management

The clients in the department are managed using a DHCP server and name server, both running on Linux. We use Symantec's Ghost to restore laboratory computer hard disks over the network when the configuration becomes damaged by student modification.

CONCLUSION

This study aims to evaluate the students' view towards using virtual teaching. The results

definitely confirm that students like this innovative teaching. As work continues on developing the teaching system, future research needs to focus on longer exposure to virtual teaching, the use of different assessment tasks, and more detailed on-line observation in order to make this confirmation. In-depth interviews need to be conducted to probe the problem-solving skills of the subjects after using virtual teaching.

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