INTEGRATION OF MULTIMEDIA INTERACTIVE WEB TOOLS WITH IN-CLASS ACTIVE LEARNING

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In this paper, we present our experience with an introduction to engineering course in which we used a combination of active and collaborative teaching methods, multimedia web-based material, and web-based interactive tools. The students were engaged in active learning in class with methods such as demonstrations, hands-on work, and group work. After class, the students used the web-based material that we developed, such as multiple choice quizzes, interactive applets, and animations. We have also developed a number of web-based course management tools that were used by the course instructors. We conclude that both the students and instructors had a very positive experience from using this combination of methods.

Introduction

In this paper, we introduce the methods we have used in an introduction to engineering freshmen course entitled, *Introduction to Computer Networks*. The course was designed with the following goals in mind: 1) to provide preliminary knowledge on the structure of the Internet (software and hardware); 2) to get the students used to collaborative team work; and, 3) to improve the students' writing skills.

In the traditional classroom, the material is presented by the instructor while students are passive listeners. This presentation style can be suitable for some students but lacking for others [5,6]. Today's students, also referred to as Generation "digital," have a very limited attention span. They are used to a number of multimedia stimulations, such as voice, video, as well as interactivity, while surfing the net. From the instructors' point of view, traditional teaching methods, especially in large classes, lead to very complex course management issues such as material distribution, homework grading, and grade posting.

To enhance the students' educational experience and simplify the instructors' course management tasks, we have used the following four components in *Introduction to Computer Networks*:

1. *Web-based instructional tools* — For the students, we developed the following modules: on-line quiz, grade check, and keyword search. And for the instructor: create/edit quiz data base, create/edit grade roster, and analyze quiz performance. This suite of tools is installed on a server computer (e.g., Windows NT) and in order to access the tools, the clients (students and instructors) need to have a web browser. The software tools have the following characteristics:
   a. Easy to use
   b. Easy access (anytime, anywhere)
   c. Platform independence (i.e., can be accessed from MAC, PC, Unix computers)
   d. No software installation is required on the students' or instructors' computers
2. *Active and collaborative learning* [1-6] — bookend, pyramid quizzes, demonstrations, hands-on experiments, group summaries, and muddiest point
3. *Multimedia course material* — multimedia class notes, animations, and applets
4. *Static web based material* — announcements, class notes, homework solutions

Figure 1 shows how these components were used by the students in class and after class.

In Class   **After Class**

Active and collaborative learning
- Bookend
- Pyramid exam
- Demonstration
- Hands-on
- Group summary
- Muddiest point

Multimedia Course Material

Web based instructional tools
- On-line quiz
- Check grade
- Keyword search

Static web based material
- Announcements
- Class notes
- Homework solution
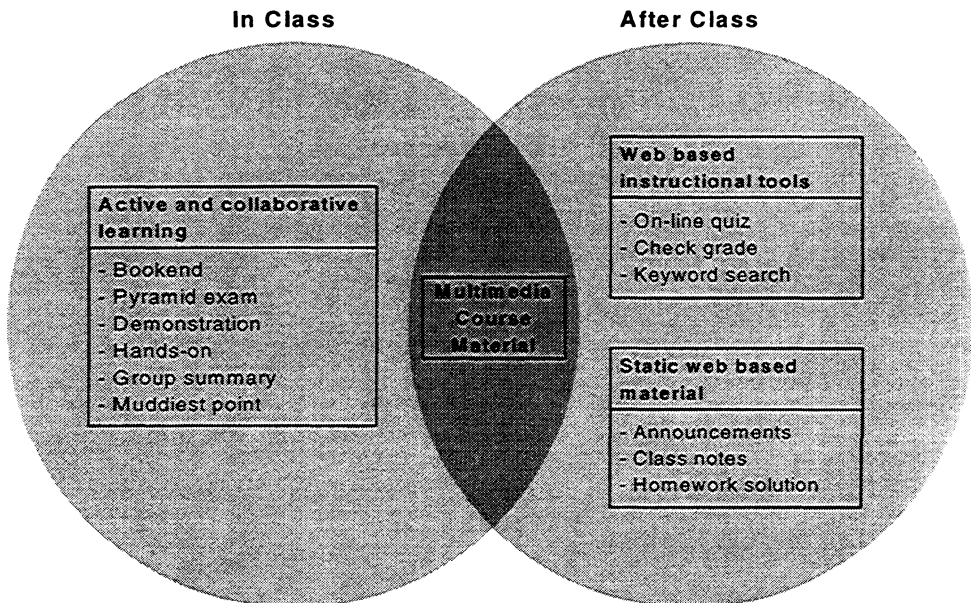
Figure 1: Integration of components used by the students in class and after class

Active and Collaborative Learning

The purpose of collaborative learning is to enhance students' ability to communicate with their teammates, develop critical thinking and problem solving skills, create positive attitudes, and increase the students' motivation to learn and understand more [2-6]. Examples of collaborative learning methods that we used are pyramid quizzes [1] and group projects.

Active teaching and learning techniques bring the course material to life, making it more interesting. These techniques also enable bi-directional communication between the instructor and students, and among students themselves. We have used the following techniques: bookend, muddiest point, demonstration, and hands-on experience.

By combining active and collaborative teaching and learning methods, the classroom becomes lively, energetic, and fun. Students not only learn more and perform better in the material, but they also learn to work in teams and improve their social interaction skills. We ask the students to voluntarily form groups of three. If they cannot find a group, we assist them.

Each lecture (75 minutes) follows a bookend structure as shown in Figure 2.

Pyramid Exam	Muddiest Point	Lecture	Demo & Hands-On	Summary
10 min.	2-7 min.	30-45 min.	10-15 min.	10 min.

Figure 2: The bookend structure [7]

The bookend lecture includes the following units:

1. **Pyramid quiz** (10 minutes) [1]: every week, there is a multiple-choice quiz with thirty questions that covers the material discussed in class during the previous week. The first round of the pyramid quiz is performed by each student individually, then these students turn in their quiz. In the second round, the same quiz is taken by groups of students, after which each group submits the quiz with their names and signatures of each group member.
2. **Muddiest points** (2-7 minutes): after the lecture is over, each group gets together and submits to the instructor, via e-mail, a number of questions regarding topics

covered in the lecture. In case there was no time left at the end of the lecture, the groups e-mail us the questions after class. Selected questions are answered in class during the following lecture and before the new material is presented.

3. **Lecture:** instructor introduces new concepts in front of the class.
4. **Demonstration and/or hands on experience:** instructor demonstrates in class the new concepts that we have introduced during the lecture and let them experiment in the computer lab. Examples of demonstrations in class are networking hardware equipment.
5. **Summary:** each group summarizes the lecture concepts in about 200-300 words per lecture. This summary is e-mailed to the instructor.

We also assign a group project—each group is assigned to work on a more accurate and elaborate summary of a particular lecture. The group project that is posted on the web includes text, figures, and links to additional material on the topics covered in the specific lecture. We provide the students assistance with web page design.

Web-Based Material

Our web based educational material is composed of:

1. Static web-based material
2. Multimedia web-based material that includes applets, pictures, sound and video
3. Interactive web-based tools that include quiz, check grade, search terms, and interactive applets

In the static web-based material, we include the class announcements, the course syllabus, class notes and also links to other activities, such as multimedia and interactive material. A screen shot of the class website is shown in Figure 3.
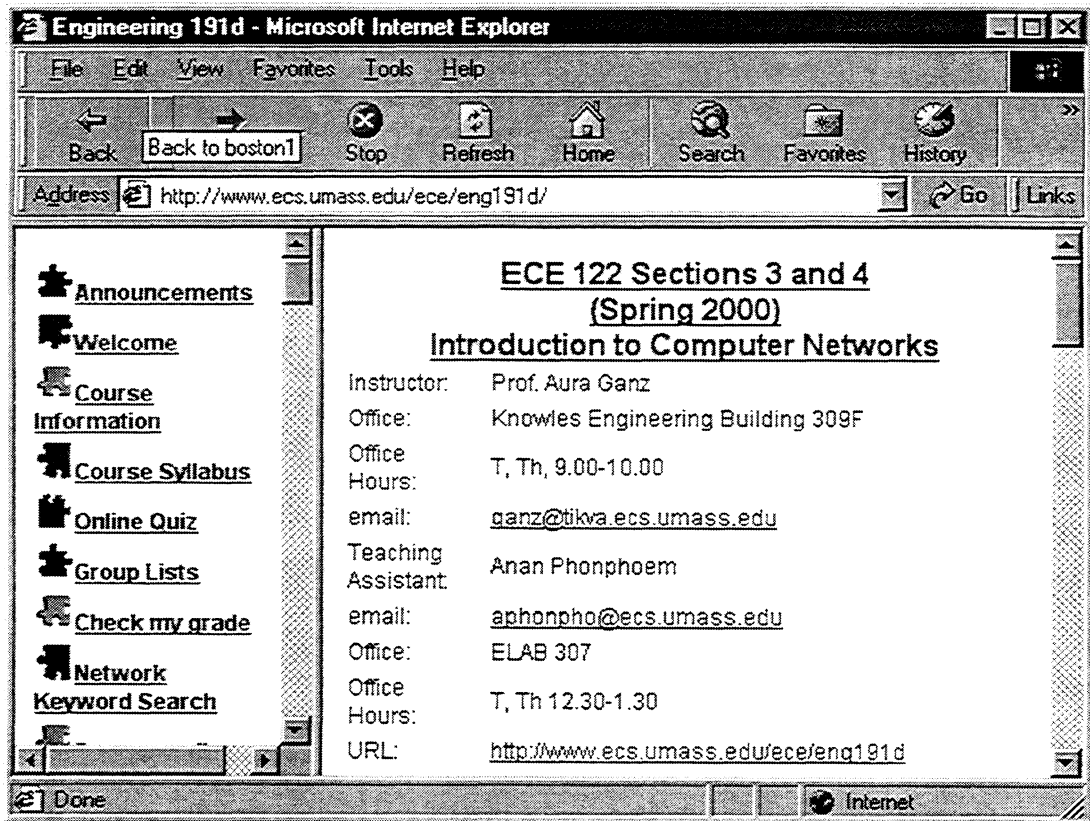
Figure 3: Freshmen engineering class website

The multimedia course material includes applets, pictures, sound, and video. Figure 4 shows an example of an animation applet integrated with the video of the instructor and Figure 5 depicts the use of photography and drawing.
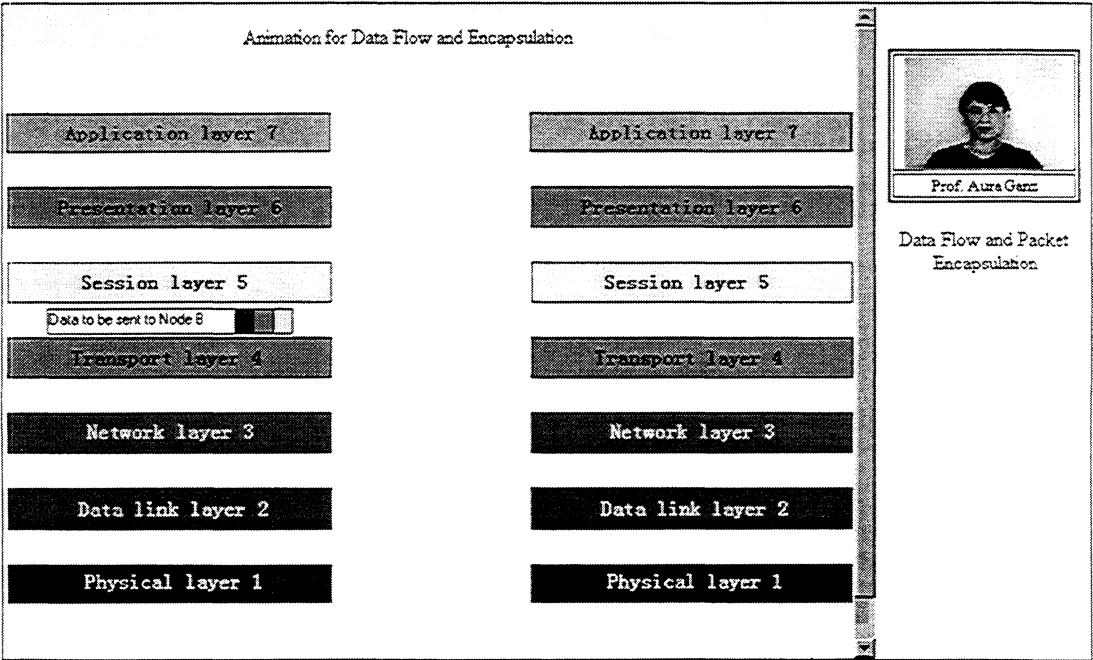
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Figure 4: Animation applet and video example
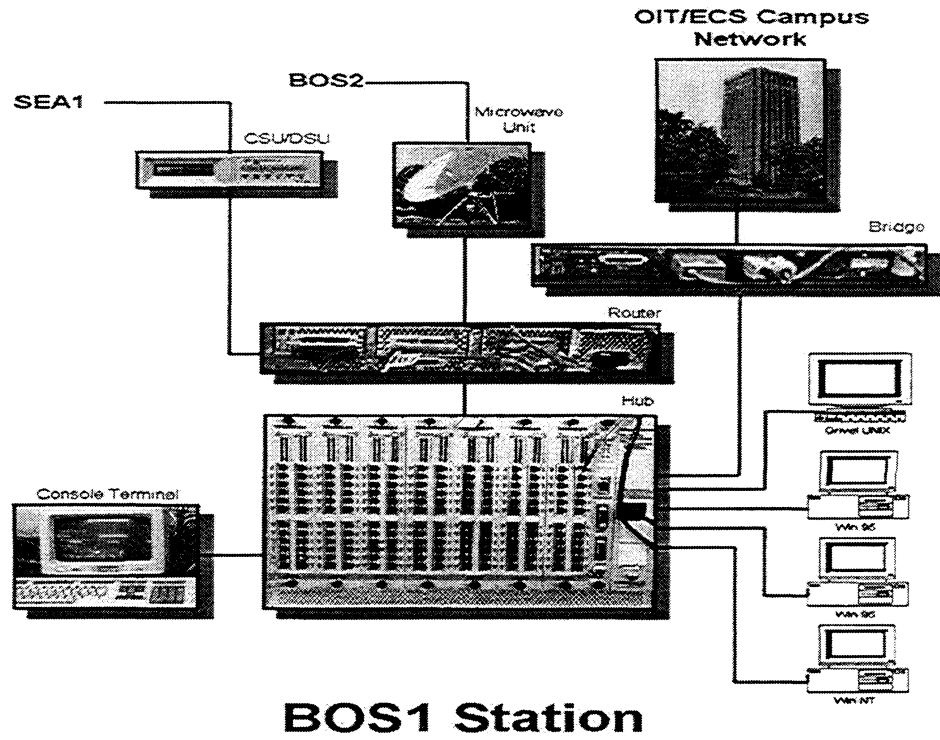
Figure 5: The networking laboratory equipment: combined picture and drawing

The students use the quiz software in order to practice for the pyramid quiz that is taken in class. The quiz software will generate a quiz on the fly from a specific topic chosen by the student. As shown in Figure 6, the software generates a multiple-choice quiz sequentially or randomly. After the student submits the multiple-choice answers, the software will grade the submission and generate another page to provide feedback to the students about their answer (Figure 7). If the choice is wrong for the question, the correct answer is displayed. In order for students to remember the question easily, the questions are also shown with the answers. The feedback also includes the score of the current quiz, the time spent on the quiz, and accumulated average score of all the quizzes the student has taken. The software has no record of students' identity, and students can leave the quiz session at any time. However, the software will keep a record of answers for further analysis.
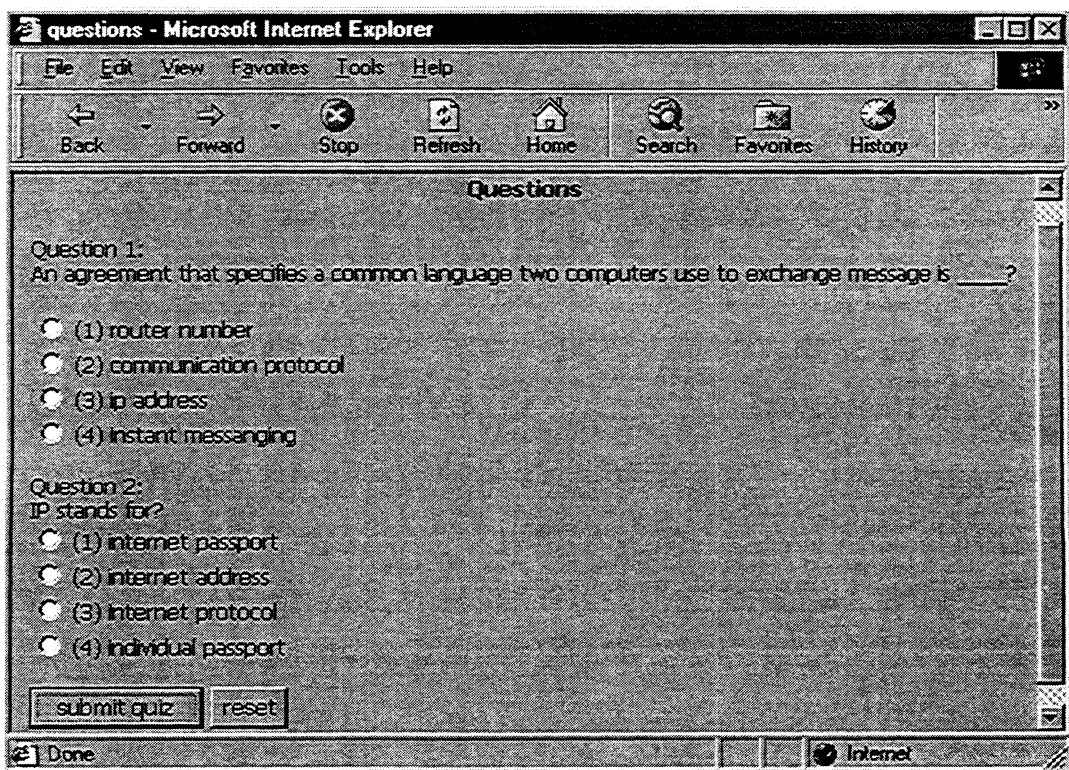

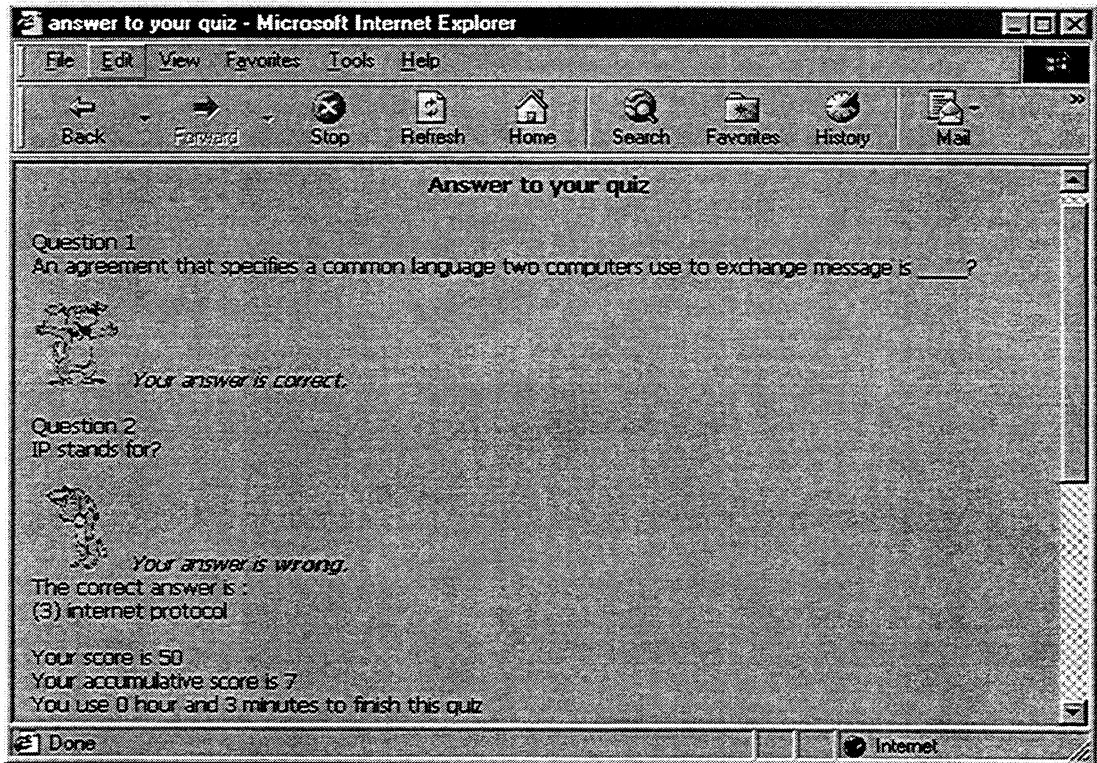**Figure 6:** Multiple-choice questions screen

Figure 7: Quiz feedback screen

Most of the students are very interested in their grades (for each homework, quiz, test) and how these grades compare with the class average. However, in order to continuously and frequently provide this information to each student, instructors spend a considerable amount of time. The check grade on-line tool can help solve these problems. Students can find their grades and the class average immediately after the instructors update this information. To protect the privacy of this information, each student accesses this information using his/her password. After a student logs in to the system using their password (e.g., student ID), the software will display the grades and class averages as shown in Figure 8. In this case, we see the student's grades and class average for the lecture summaries (lect2 – lect9) and for the individual (Ind.Quiz) and group part (GrpQuiz) of the pyramid quizzes. Since each assignment in class has a different weight, the students can also learn these weights by clicking the "Show me weight" button.
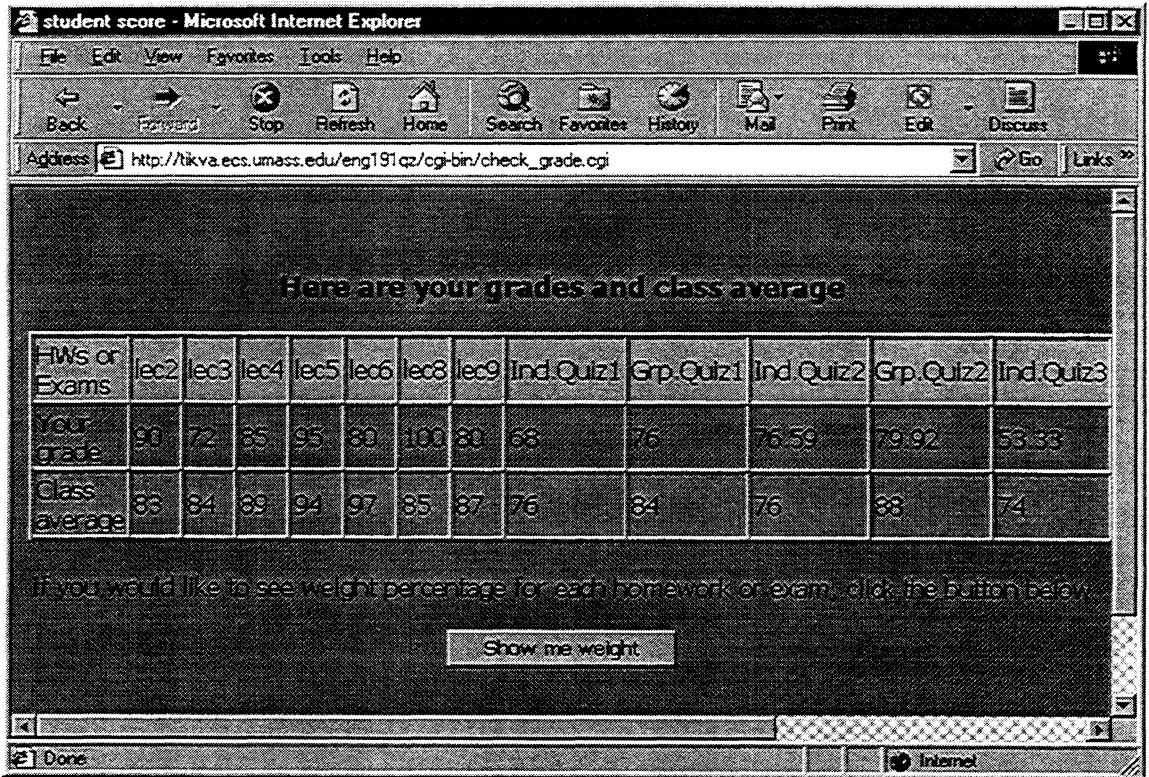
Figure 8: Check grades on-line screen

We have also implemented a search term tool that provides the students with the option of checking definitions of networking terms. A screen shot is provided in Figure 9.
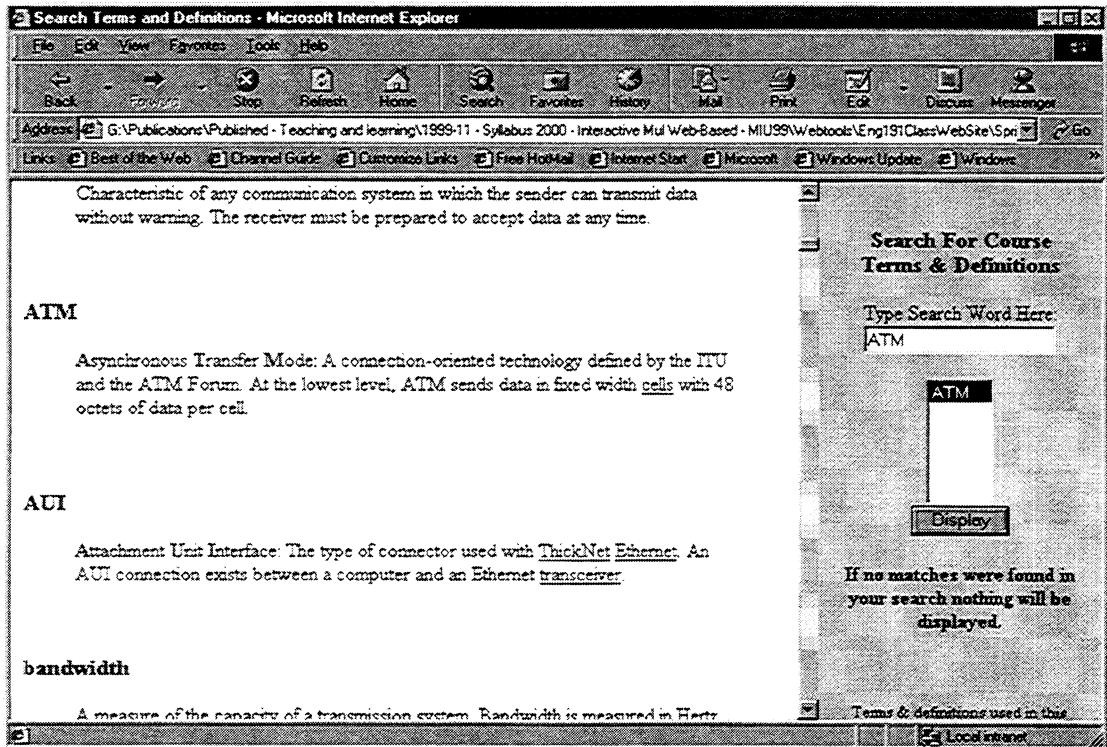
Figure 9: Search terms screen shot

We are currently developing a number of java applets that will be used in future computer networks courses, e.g., the shortest path applet presented in Figure 10. The applet technology gives students the opportunity to interact with the software by changing a number of system parameters and viewing their impact on the network behavior. For example, in the shortest path routing applet the students can define the network topology, link weights, the source and destination, etc. The students can view both the graphical and text output of the shortest path algorithm, improving the students' understanding of this algorithm.
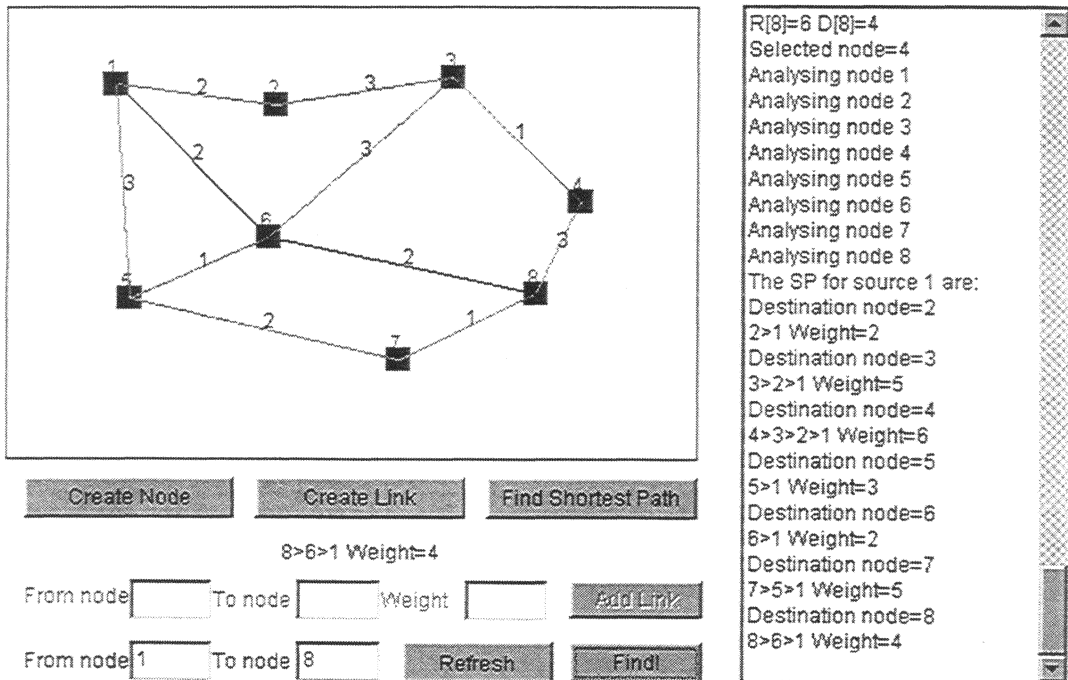
Figure 10: Shortest path applet screen shot

On-Line Class Management Tools

There is a large amount of information that needs to be managed by the instructor, i.e., the quiz file, the grades file, student information, etc. The administration software is password protected and can be accessed only by the course instructors. Access to the administration software is through a browser, leading to platform independence for the instructor.

There are four sub-functions in the administration module: view file, edit file, create file, and analyze results. For example, if the view file option for viewing the grades is chosen, the screen shown in Figure 11 will be displayed.

If the edit file option is chosen, the instructor can edit many different files (e.g., students' records, quiz file, grade file, etc) using a java-based interface as shown in Figure 12. The editing is done locally and only when the instructor saves the file are the file contents updated on the server.
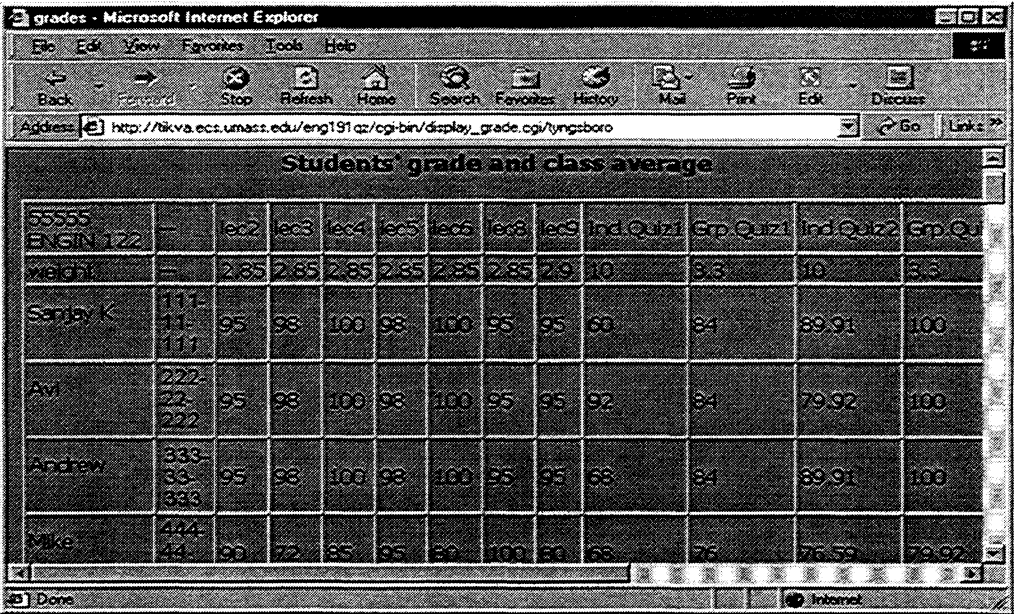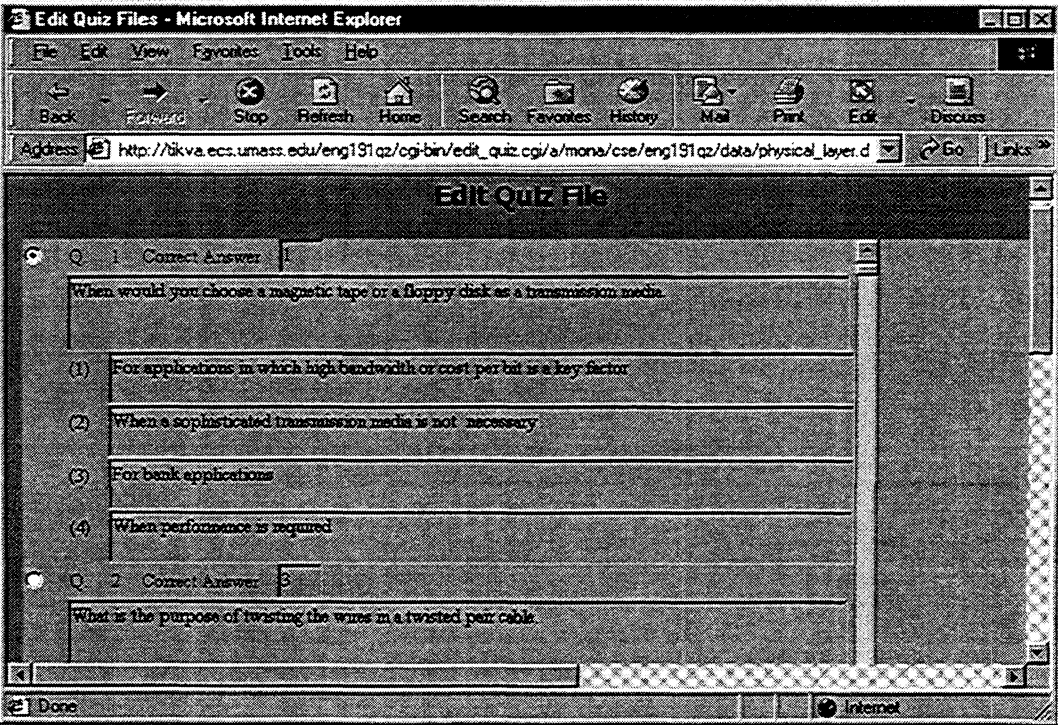
Figure 11: Students' grade
screen

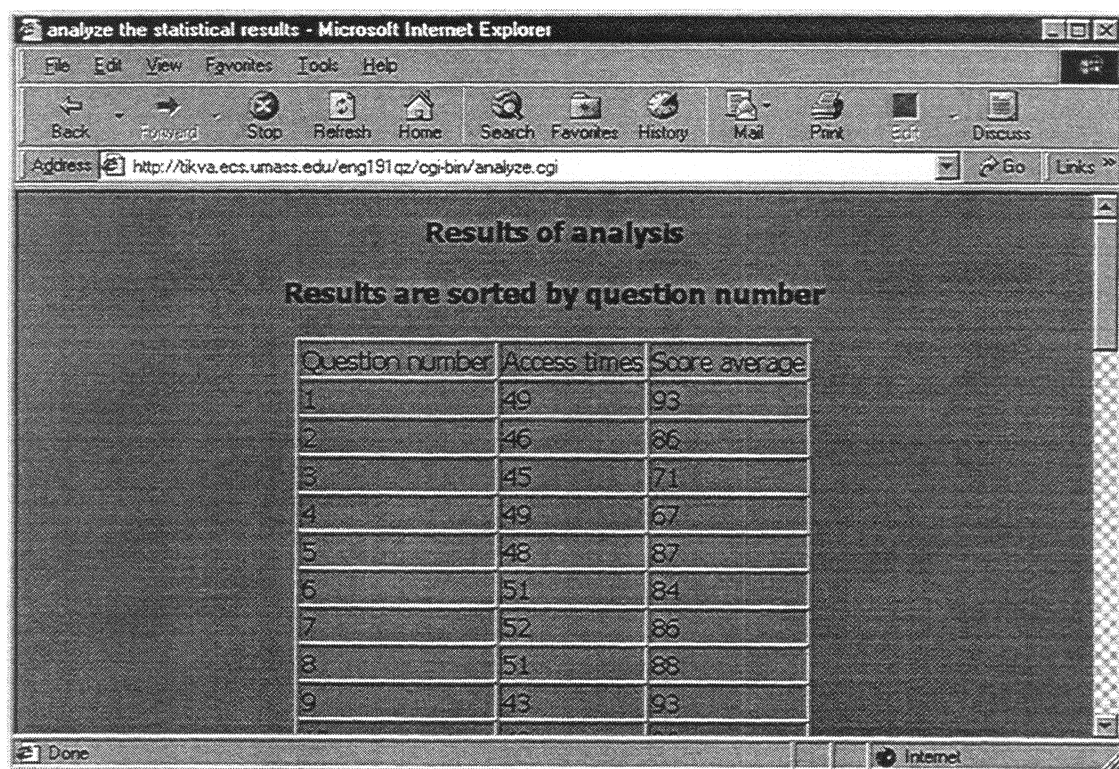**Figure 12:** Java-based interface for editing the quiz file

Figure 13: Results analysis screen (sorted by question number)

When students take the quiz, the software that grades the quiz saves statistical information that includes time, question number, and answer. Each quiz file has one statistical file associated with it. This file can be used by the instructor to analyze the students' performance. Clicking "analyze results" button on the administration page enables analysis of the statistics collected so far. There are three methods to analyze the statistical files. First is to display results according to the question number, second is to display results according to percentage of correct answers, and third is to display only partial results (such as choosing only easy questions or difficult questions).

Figure 13 shows statistical results sorted by question number for a specific chapter. The table shows how many times each question is accessed, and the average score for that question. If you are more interested in the difficulty of the questions, you can use the second analysis method that sorts the questions by percentage of correct answers. An instructor can use this information for clarifying the concept in class or just reformulate the question or answers.

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We found from these statistics that each question in the data base was accessed numerous times, i.e., the students use the quiz tool very often in order to practice for the pyramid quiz taken during class time. We do not have any statistics regarding the identity of the students that took the quiz. As explained before, the students prefer to stay anonymous so that they can practice the quiz as many times as needed without being monitored by the instructor.

Feedback

We evaluated the students' satisfaction with some of the components we have used. Table 1 provides the results we collected from all 55 students who took the class.

	Students' feedback (% of total students)	
	Satisfied	Dissatisfied
Muddiest points	71	29
Pyramid quizzes	92	8
Hands-on demonstrations	98	2
Quiz website	83	17
Course website	100	0

Table 1: Student feedback on a number of components we used in class

We observed the following:

- For muddiest point, 29% of students were not satisfied because the muddiest point assignment is counted toward the students' grade
- For quiz website, 17% of students were not satisfied because the on-line quiz material contains some typos and wrong answers; this result leads us to consider adding a feedback or bug report page included in the class website, and it would be a good process for polishing the material
- Students seemed to be more interested in the hands-on demonstrations on network hardware/software components
- Homework/project grading was easy and fast
- Students preferred to form a group by themselves rather than be assigned by the instructors. Voluntary groups have shown better results in the projects.

Summary and Future Work

In summary, our experience teaching this course was very positive. We have enjoyed observing the students participate and show interest in class as well as in the after class activities. Based on the students' feedback presented above, we conclude that this was a successful

experience for the students. Obviously from the instructors' perspective, it provided considerable savings (time, photocopying, paper).

Our next steps in this project are to: 1) enhance interactivity through animations of abstract concepts and multimedia (video and voice) contents; 2) interact with STEMTEC project to better understand the learning processes and course assessment methodology; and, 3) obtain constant feedback from students and instructors.   ■

Acknowledgments

Bio

Professor Aura Ganz is the Director of the Multimedia Networks Laboratory at the University of Massachusetts Amherst (UMass). Her research interests include multimedia networks, web-based instructional technologies, wireless networks, security, and high speed networks. With her graduate students, she has developed web-based instructional technology software that was implemented in a number of undergraduate and graduate courses at UMass. She has received the Best Paper award in Foundations in Education Conference 1999. Prof. Ganz received her Ph.D. in Computer Science from Technion, Haifa, Israel. She has published over 120 papers in various journals and conferences. Prof. Ganz is also the co-founder of a UMass spin-off, EnrichNet, Inc., that provides software solutions for multimedia support in wireless and wired LANs.

Prof. Anan Phonphoem received his Ph.D. in Electrical and Computer Engineering at the University of Massachusetts Amherst in May, 2000. His research interests are computer networks, wired-wireless LANs and protocols. He received his B.Eng in Electrical Engineering from Prince Songkla University, Thailand in 1990. Between 1990 and 1991, he worked for Advanced Micro Devices (Thailand) as a reliability test engineer. From 1991 to 1994, he worked for Nawaloha Industry Co., Ltd., Thailand, as an engineer. In 1994, he received a scholarship from the Royal Thai Government, Thailand, to pursue his M.S. and Ph.D. studies in the U.S. In 1996, he received an M.S. in Computer Engineering from the University of Southern California.

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