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Deliverable, Low-Cost Student Response Systems

ABSTRACT:[1] This paper describes three deliverable, low-cost student response systems - software tools for providing instructors with immediate feedback on students. Each of these tools has been and is being developed at the United States Military Academy for similar purposes. First, the software can be used as a lesson structuring tool. Instructors can tailor their presentations to classes based on the results of their students' lesson preparation the night before. This results in classes that are specifically targeted at those subjects the students had difficulty with. As a result, the instructors can better utilize their class period and the students will find the classroom instruction more valuable. Second, we have used the software during class to validate that the students understand a particular learning objective before moving on to the next learning objective or to tabulate the class' opinion on a student submission anonymously. Due to the automatic, real-time grading of results, the student response system allows greater control over class presentations by providing relevant feedback to the instructor and the student in real-time. Finally, the student response system can be incorporated into courses taught using hypermedia. As before, the system provides critical feedback to the student and instructor alike and allows for the tailoring of study sessions and course material respectively.

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INTRODUCTION - THE PROBLEM

The United States Military Academy presents an interesting and challenging environment for teaching undergraduate courses. While the students are highly motivated, they must balance many demands on their time. Each student must take a rigorous and broad academic curriculum. Each student must also participate in intramural or collegiate athletics as well as fulfill the normal requirements of military life. As a result, cadet life is fast-paced and challenging. Time becomes the most precious resource. We need a mechanism to maximize the value of the classroom lecture so that the cadets learn as much as possible in each 55-minute lecture. Principles of classroom assessment provide the pedagogical basis for our student response system (Angelo, 1994, pp.1-10). Eliciting frequent feedback on student learning and responding to that feedback is a goal that is often difficult to realize in conventional classroom situations. As a result, we are developing an automated, network student response system that allows the instructor to tailor the presentation of each class to each particular section.[2] Furthermore, we needed a rapid mechanism to evaluate if our students are understanding the material we covered as we progress through a class. Finally, we are in the process of developing a hypermedia approach to teaching one of our courses and need an assessment module as a component of this approach. This paper details our solution to these three problems.

THE SOLUTION

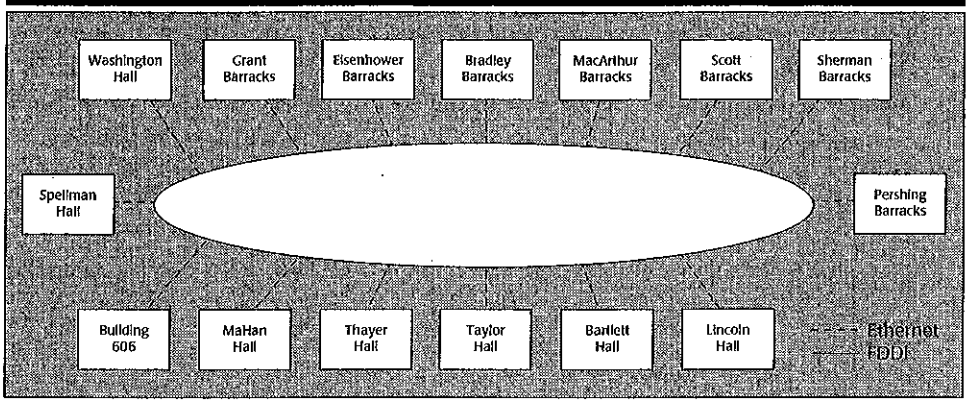
We have or are in the process of

The views expressed in this paper in no way express the official position of the United States Military Academy, the US Army or the Department of Defense. All insights are the authors' own.

Key to lesson tailoring is small classes. All of our classes have a maximum of eighteen students.

developing three solutions to these problems. Let's look at each of these systems briefly. Key to each of these solutions is network access.

FIGURE 1. West Point Computer Network



Network Access

Key to the success of distributed multimedia is a supporting network. The United States Military Academy is fully networked (see figure 1) and the Academy has issued each student a PC computer that connects to the network.[3] Ethernet segments connect PC computers to an FDDI ring spanning the entire campus. Through their personal computers, cadets can access distributed file servers and the course material contained therein. A Pentium 60MHz network server running Windows NT/Advanced Server provides access to the course files. Students access the file server using Microsoft LAN Manager and Microsoft Windows File Manager. Using this approach, the students can get to course material anytime they desire.

The Visual Basic Student Response System

The first student response system is a suite of Microsoft Visual Basic programs designed to provide an assessment to the instructor and student on student comprehension of course material (see figure 2 and 3). Its sole function is to provide feedback to the student and instructor so that both can prepare appropriately for class. It is a networked application allowing student and instructor access to networked assessments over a campus area network (CAN) (see figure 1). Finally, it is a set of file-based input/output applications that provide the following functions: (1) Simplified Assessment Generation, (2) Real-time, Automatic Grading, and (3) Multiple Instructor and Student Interfaces.

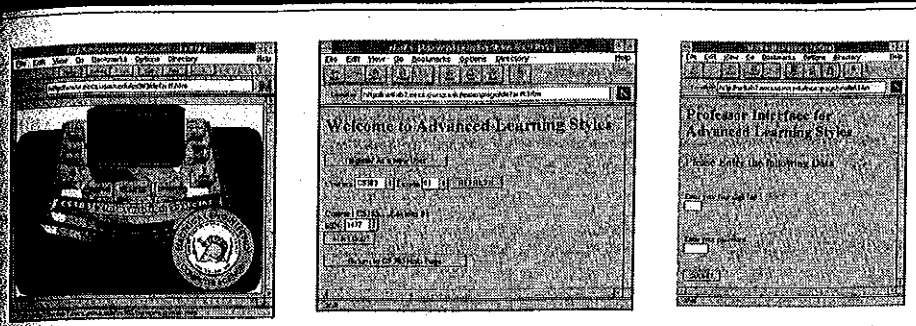
1. We simplified assessment generation through a companion program that generated properly formatted test files. The instructor enters a set of questions, the possible choices, lesson objective, a reference for the question, and the correct answer. After the instructor enters the test material, the quiz file is automatically generated. Currently, we are developing applications that support multiple choice, true/false, matching, fill-in-the-blank, approximate analogies, directed paraphrasing, one sentence summaries, and one minute paper-type questions (Angelo & Cross, 1993). Of particular interest, we are exploring the possibility of nondiscrete assessment using multiple choice questions (Paul & Supon, 1994, pp. 17-21). While this is only a small subset of the possible types of questions, these types of questions are well-suited to providing the instructor and student with a quick assessment of understanding of course material.
2. Assessment tabulation is automatic with the results calculated and summary information provided in real-time. This provides students with immediate feedback so that they can revisit material that was not understood. Since the material is available over the network, students can alter the course of their study in their room to revisit material that is not fully understood. It also provides the instructor with a mechanism to alter the course of instruction both before and during lessons.
3. Finally, the interfaces into the same testing engine allow the suite of programs to be used for different purposes. Students have an interface they use for lesson preparation in regular classes and a different interface for use as part of a course hypermedia application. Instructors have an interface for use in class and a different interface for use before class for lesson tailoring. Each of these interfaces optimizes the functionality of the base testing program for a specific use.

Lesson Structuring Tool

As a lesson structuring tool, the student response system allows the instructor to rapidly and quickly tailor the presentation of course material to the material each section does not understand. Completing each lesson's self-assessment is considered part of lesson preparation before class. Each student takes the exam in his room and the results of the exam are calculated and copied to a shared directory on a network server. If students do poorly, they can retake the exam as often as they like to update their results. The instructor interface for lesson structuring uses the student results from each section and provides the instructor with feedback before class to include: what learning objective the students understand, which ones they had difficulty with, and how many students did not bother doing their exam by section. This provides the instructor with insight

3 *Cadets pay for the computers issued to them over approximately a two-year period.*

FIGURE 2. Mosaic and the Visual Basic Response System



before class about what material needs to be emphasized in class and what material can be omitted because the students already understand the subject matter. In some courses, we have developed formal supplemental lessons to take advantage of this feedback to cover more advanced material with classes that can handle the advanced material (Carver & Biehler, 1994, pp. 87-92).

This tailoring of class content enhances student comprehension by making each lesson more interesting by covering only that material the students do not understand. Tailoring of class content also enhances the instructor's presentation of course material because each lesson is different and as a result, the instructor's presentation of that material is more dynamic and fresh.

Quick Student Response Query

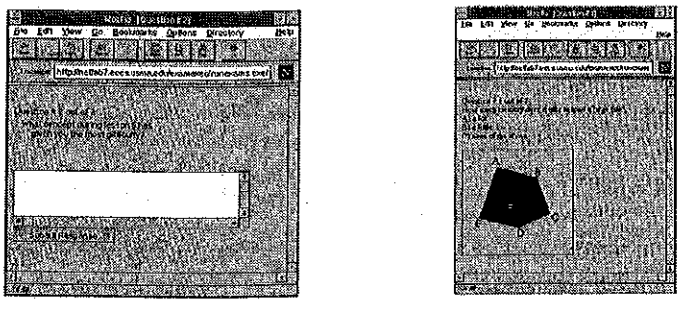
The student response system is also used in class to quickly measure student comprehension of learning objectives. As the instructor is presenting material, there is often some question as to how many students are understanding the material. For a variety of reasons, students do not always ask questions when they do not understand the subject matter being covered. This lack of communication between the student and the instructor hinders student learning. This is especially so if the material being presented is dependent on the material previously covered in class. By missing the first learning objective, the student may be lost for the rest of class. The student response system alleviates this lack of communication between the instructor and student by providing the instructor with the information necessary to quickly measure section understanding of course material. Because the student response system provides real-time grading of results, it is ideal for the 1 minute assessment to measure student understanding of the material just covered. Armed with this information, the instructor can then reemphasize lesson objectives that are poorly understood or move on to the next learning objective. Key to this approach is providing the instructor with the right information at the right time. The student response system provides this information.

Component of the Hypermedia Information Systems course

Finally, the student response system will be incorporated into CS383, Information Systems, which has been converted from overhead transparencies and reading assignments into a rich hypermedia course consisting of hypertext, audio, graphic, and video files linked together using Mosaic (Carver & Biehler, 1994, pp. 87-92). Capitalizing on the network-rich environment we operate in, we used the Windows Sockets version of Mosaic as our interface into course material. Reading assignments were supplemented with hypertext documents linked into Mosaic pages. Overhead transparencies were converted into Harvard Graphics Slideshows that in turn were supplemented with sound files, 256 color graphics, and video clips all of which are linked into Mosaic pages (see figure 2 and 3). While these tools provided the students with greater control and flexibility as to how and when they learned the course material, we needed a mechanism to provide the students with feedback as they learned course material. The student response system met this need. The student interface into Mosaic quizzes was distributed and the quizzes themselves were embedded in the Mosaic pages corresponding to particular lessons. As before, the key is providing timely information to the students so that they tailor their study sessions.

Furthermore, based on the results of the student response system, the instructor could then revisit the material contained in the hypermedia documents and modify the contents based on those subjects that the students were having the greatest difficulty with. This critical feedback prioritizes

FIGURE 3. Visual Basic Response System and Question Types



the development of additions to the course document to those areas most critical - the ones the student is having the most difficulty understanding.

The Microsoft Access Database Solution

We are developing the second student response system using Microsoft Access. It is a network-based, database solution that is designed to accomplish three goals. The first goal is to provide a real-time, computer-based question-answer session that can be used as both a tutorial and an evaluation instrument. The second goal for the system is to serve as an expert system for capturing the knowledge of all instructors associated with a course during a given semester. The third goal is to exploit the network at the USMA by delivering tutorials over the network to multiple cadets simultaneously.

Real-Time, Computer-Based Question-Answer Session

The typical homework assignment for a student consists of a reading assignment and a number of questions at the end of a chapter. The questions associated with a reading assignment are often good questions but they may lack the answers or they may only cover only a portion of the material. There should be a system that provides more questions and answers for a student short of the student having to acquire additional texts on the same material. This need can best be served by a database system that consists of tables of questions and answers associated with learning objectives. Our database system is being designed to provide a series of random questions based on lessons. The questions will be of the form of true/false, multiple choice, and matching. The tutorial and evaluation instruments vary only in that the latter is used to grade the cadet. Both instruments will provide feedback that is instantaneous and a key component of that feedback will be the historical record of the performance of past cadets on the question. Feedback can serve to motivate cadets if they are given information as to their performance in relation to other cadets. Additionally, cadets will have an indication of the difficulty level of the question based on the performance of cadets who have previously tried the question. Both systems will randomly draw from the database of questions and will feature time limits to force student response in real-time and without massive reference searches. Answers will be provided and time allowed for the cadet to make a note on the question before proceeding. A cadet will be allowed to execute as many tutorial sessions as desired. This will serve to establish a correlation between how much time cadets spend on a course and how well they potentially perform on an evaluation test using the system. The other key design feature is the inclusion of questions from past material. We believe that this will aid a cadet in his retention of all course material.

Instructor Expert System

The majority of the instructors at the USMA are rotating faculty. There is currently no computer-based system for capturing the body of questions and answers that instructors develop for a course and transferring that material to new instructors. A key component of this system will be the expert system that allows the instructors teaching a course to input their questions and edit past questions to reflect the changes in course material. Over time, the database could grow to contain hundreds of excellent questions for each learning objective. Using a random sampling of questions, each cadet may not see the same question on an assessment even if the tutorial is executed several times. If the system is used in the classroom, no two cadets may be taking the same exam because of the random sampling impact of the system.

Exploiting The Network

Every cadet has a personal computer on the desk in his barracks connected to the network (see figure 1). Using a single file server that course directors have easy access to, we can efficiently deliver and manage tutorials using the network. A networked student response system also allows us to record information on the performance of individual cadets throughout a course and not just at the traditional major graded exercises. This provides more timely and consistent feedback to the cadet throughout the semester. We believe this feedback will result in better performance.

Selection, Voting and Tallying Tools in C++

The third set of programs has been developed specifically to exploit a local area network (LAN) in the classroom for interactive teaching purposes (see figure 4). We set out to add selection, voting, and tallying support to a classroom already equipped with a rather expensive radio-based system which we found unreliable and difficult to use. We proved that the existing LAN was superior for communicating student responses to the instructor. The desired functions were:

- Allow students to rapidly select answers to a verbal multiple choice question during class and provide an anonymous, publicly displayed histogram of the answers. The instructor thus obtains immediate feedback on the general level of understanding. Each student finds whether he or she is "with the pack" in understanding, or an outlier. No one is embarrassed.
- Allow students to anonymously score the presentation efforts of others. Immediately after a student presentation, the instructor asks the other students to score various aspects on a scale of 1 to 9. An immediate publicly displayed average of the result provides rapid feedback. A low or high score provokes discussion.

Classroom LAN implementation

Our classrooms contain eighteen

student desks with a computer on each. These are connected by a standard Ethernet to a classroom server. The instructor has a computer similar to the students' but with a large monitor for public display. The LAN and server allow Microsoft Windows software running on all the student and instructor machines to share a single directory. The student machine passes messages by writing files in the shared directory that the instructor machine subsequently reads.

Vote and Tally Tools

Such simple message passing is sufficient for our implementation of in-class voting and tallying tools. The student voting tool is a small Windows program that resides on the server. A student starts it running by clicking an icon with the mouse. Each running version of the program gives itself a unique name by noting the time it starts to the nearest millisecond. The program displays a small window with some labeled buttons and a box showing the last button pressed. A button press comprises a selection or vote. It causes the program to write the button label to a file in a shared directory on the server. The name of the file is the same as the unique name of the running voting program. Hence when eighteen students have voted, there are eighteen files in the shared directory containing the votes.

The tally program is another simple Windows program that runs on the instructor machine, with its Windows display visible to all on the large classroom monitor. The program performs two functions. First, every two seconds, it counts the number of files in the shared directory and reports how many votes are present. Hence, as soon as the instructor asks the students to select or vote, all eyes can watch the tally in progress. Second, at a button press, the program computes the results in the desired form — histogram or average — and deletes the student vote files in the shared directory.

Configuring the Tools

The structure of Microsoft Windows is a boon for tailoring the interactive tools. The core of the tools is written in C++ (using Borland compilers). However, the description of the Windows controls — buttons, message list boxes, etc. — reside in the finished program as so-called resources that can be edited with graphical tools (like Borland's Resource Workshop) that require no knowledge of C++. It is a simple matter e.g. to produce versions of the voting tool with different arrangements of buttons and labels. Making the new tool available for class is a matter of copying it (once) to the server where the student's icons already point to it. A general purpose tally tool can be modified in a similar manner.

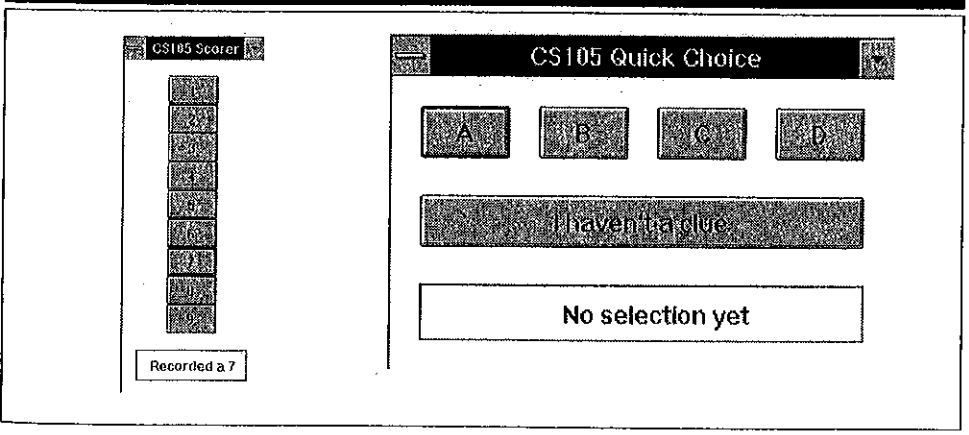
CONCLUSION

Key to effective learning is open communications between the instructor and the student. Student response systems facilitate this exchange. They allow the instructor and the student to alter class presentations as well as lesson preparation so that time is used in the most effective manner possible. While it remains to be proven, we feel this can only enhance the student's educational experience as both the student and instructor have greater flexibility and control. By providing critical information at the right time and in the right format, the student response system empowers both students and instructors alike and enhances the educational process.

FUTURE WORK

While the student response system provides critical information to the instructor and student to facilitate maximum learning, there is a preparation time cost associated with preparing quizzes using the system. As stated in (Schank, 1994, pp. 69-78), this economic cost must be validated by either better student performance or less lesson preparation time. Given our dependency on lesson objectives for generating exams, we are particularly concerned with the amount of work generated by changing the learning objectives. We will evaluate these systems in the Fall term 1995 in several courses.

FIGURE 4. Variations of the Scoring Tools Produced with a Graphical Editor



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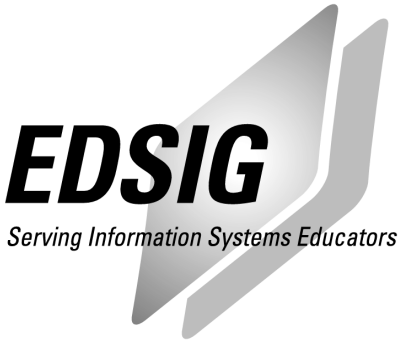

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