Abstract

Classroom feedback constitutes an important diagnostic tool for a learner-centered classroom environment. Student access to a networked computer in class is becoming more commonplace, and offers an additional communications channel between the student and the instructor. A software system has been developed which simultaneously collects text messages from all students in the classroom in response to a question posed by the instructor, and immediately displays the students’ responses to the instructor. The process is fast and paperless, and can provide a wealth of detail about the thought processes of each student. The system was implemented using the Perl scripting language, and was used to support the activities of a sophomore-level electrical systems course conducted in a classroom containing a networked NeXT workstation for each of the 23 students. The system was used to administer quizzes and collect results from in-class projects, but proved to be most useful for collecting responses to short concept-oriented problems designed to expose misconceptions. The students would type a short answer or multiple choice selection followed by an explanation of their reasoning. The short responses were used in class to assess the learning status of the class as a whole, while the explanations provided specific and individualized diagnostic information useful for tailoring subsequent class sessions.

Introduction

Classroom feedback constitutes an important diagnostic tool for maintaining a learner-centered classroom environment [1]. Feedback that occurs while the class is in progress is most effective since it allows the instructor to dynamically tailor activities to meet the needs of the students. Traditionally, instructors pose a question and ask for a verbal response. This method has the advantage of establishing a dialog between the students and instructor, but has several disadvantages: only a limited number of students are able to respond to the instructor, students usually need time to formulate a response, and students often do not like to volunteer a response in front of their peers. Educators have devised alternative methods to address one or more of these problems, including activities such as “think-pair-share” (a popular cooperative-learning activity which gives students time to form a response and consult with a neighbor to gain more confidence) and the one-minute paper. “Think-pair-share” also limits the number of responses, and the one-minute paper can only be processed by the instructor outside of class. A technique is needed that will enable each student to respond without fear of criticism while class is in session.

The computer network has emerged as an alternative communications medium between student and instructor. Chat rooms, newsgroups, web pages, and e-mail are increasingly used by instructors to facilitate student-instructor and student-student communication outside the classroom [2-3]. Intraclassroom communication systems have been devised that allow the students to make multiple choice and yes/no responses in real-time: for example, the Consensor classroom [4] uses keypads at each student’s desk connected to a single PC which converts the student responses into a bar chart summary which is displayed on the wall screen. The system rapidly elicits a response from each student and maintains anonymity. A major drawback of this type of system is its inability to accept an arbitrary response, hence it is not possible to obtain information about the thought process behind a response.

The system described in this paper addresses the needs for real-time classroom feedback by allowing each student to type a response at his/her own networked computer, and by making these responses instantly available to the instructor.

Implementation

The intraclassroom communications system developed here requires the following elements of existing hardware/software infrastructure: (1) networked workstation for each student in the classroom, (2) read/write access to a common file system, and (3) Unix and Perl scripting languages. Other platforms such as
Macintosh and Windows could be used as well, provided that an appropriate programming or scripting language is available. The specific system used for this work was a classroom containing 30 NeXT workstations, and a 486-based laptop for the instructor.

The networked file system provides the basis for communicating between scripts executed by the instructor and students. Each student is granted write permission to a unique subdirectory where his/her response textfile is placed. Each student has read permission for a common subdirectory where the instructor's question textfile is placed. The subdirectory structures and permissions guarantee privacy for the student responses and instructor questions (prior to being posed), making it possible to use the system for graded work. As a further security precaution, students must be logged in at the console of each workstation to participate.

The instructor begins the process by devising a question, which may be prepared in advance and stored in a textfile, or may be typed in class. If required, supporting graphics are placed on the whiteboard or overhead projector. The instructor-script places the question in the common directory, clears existing student responses, and displays a status indicator. The status indicator shows elapsed time and a bargraph to indicate the percent of completed responses. Students respond by executing a common student-script which reads and displays the instructor's question, and prompts the student to enter a response. The student types arbitrary text which is subsequently stored in the student's personal subdirectory. Once all students have responded (or when the instructor decides to move on), the instructor-script prints a report showing student name, physical location in the room, and response.

Since the response medium is text-based, the students have a great deal of freedom when generating a response.

Results

The system was implemented, tested, and refined during use in the first offering of Electrical Systems, a sophomore-level electrical systems class which is part of the Foundation Coalition Sophomore Engineering Curriculum [5]. The class had 23 students, and many were enthused about using the system and offered suggestions for improving it.

![Figure 1. Example Circuit for Short Answer / Explanation Question](image)

The system is fast (barring difficulties with the network itself) and presents no significant load on the workstations or network since the data exchanged are small text files. Eliminating paper as a means of communication means less downtime for paper shuffling and more time for active discussion.

Almost all students would respond to a given question. Since today’s students are accustomed to communicating via computer using e-mail and newsgroups, talking with their instructor via the computer comes naturally. Moreover, since students are able to respond simultaneously, they do not have to wait for other students to finish talking as in a traditional verbal-only response. Consequently, the instructor has the potential to be provided with a large amount of data for each question.

Throughout the course, I experimented with a variety of question formats including multiple choice, true/false, short answer (one or two words), and short answer supplemented by explanation. The brief answer format works best for testing knowledge-level information. To probe higher order thinking skills, I found a short answer followed by an explanation of the answer was the most useful question format. Since students are sensitive to downtime [6] (even a delay of 10-15 seconds is enough to break the flow of activities), it is not feasible to try to read sentence-type responses in class, so the short answer provides a first-order approximation for the aggregate class understanding. After class, reading the explanations provides insight into the students’ thought processes.

For example, one or two days after discussing voltage dividers, I placed a circuit diagram (Figure 1) on the overhead projector, and asked “What is the value of $V$?
and how did you find it?” I have used this question in previous introductory circuits courses, and knew that it usually provoked some discussion about how a voltage signal can be transferred apparently unchanged across a resistor. Once the students responded, my quick scan of the report convinced me that about half of the class understood the concept resulting from the following logical sequence: the open circuit implies zero current through the resistor, which implies zero voltage drop across the resistor, which implies that the 5 volt potential appears at the right side of the circuit.

However, upon reading the explanations after class I discovered that only one of the nine students who produced a correct response used correct reasoning! Three students used the two-resistor voltage divider formula and concluded that since one of the resistors was missing, one of the resistance parameters in the denominator should be eliminated, yielding \((R/R)*5 = 5\) volts. Other students either used incorrect reasoning or simply guessed. These specific results formed the basis for fruitful subsequent class discussion.

Student comments about the system indicated that they generally liked using the system, although some aspects could be improved. For example, since only one question could be active at a time, multi-part questions for long in-class activities were awkward. Some students would race ahead while others needed more assistance, so making only one part of the question active at a time caused difficulty. In addition, students wanted the ability to correct an answer.

I discovered that the system needs to be used in moderation. I used it frequently during the first weeks of the course and as a result felt somewhat estranged from the students. The class and I became more comfortable when the system was used to supplement traditional dialog.

**Summary**

A system has been developed by which students can respond to instructor-posed questions by typing arbitrary text using networked computers. The technique has the following advantages: students have time to formulate a response, students can make a private response without fear of criticism from their peers, the system is fast and paperless, and the instructor is able to learn the thought processes of each student. Classroom testing of the system showed that almost all students would respond to a given question, and that the responses provided the basis for targeting specific misconceptions.

**References**