Development and Initial Experience with a Laptop-based Student Assessment System to Enhance Classroom Instruction

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Abstract

New principles of learning and instruction highlight the need to engage students in thoughtful use of knowledge. However, engaging individual engineering students in large classrooms simultaneously can be challenging. Classroom communication systems (CCS) encourage students to apply conceptual ideas during class, by allowing them to respond to questions using hand-held devices. A real time aggregate of their responses reported to the instructor and/or the class can provide valuable feedback to both to the instructor. The VaNTH (Vanderbilt, Northwestern, Texas, Harvard/MIT) Engineering Research Center for educational technologies has experimented with commercial versions of these systems with great success. However, such systems generally support only multiple-choice questions, and usually require proprietary hardware and software. We have developed a browser-based solution, the VaNTH Student Assessment System (VSAS), to provide richer modes of questioning and better utilize our existing technical infrastructure. VSAS allows for multiple choice, short answer, and essay responses to questions during class by using student's wireless laptops as input devices. Free-text response capability may increase learning potential because students need to rely more on generating knowledge and less on routine recall of memorized information. Moreover, the system lends itself very well to implementation in models of challenge-based learning that include phases of generating ideas and revisiting initial intuition after instruction. Finally, VSAS compliments the engineering school's initiative to embed the use of technology with classroom instruction through wireless network infrastructure and laptop computers to all students. This paper presents several examples illustrating the value added by using the short answer and essay features of VSAS. These cases highlight the instructional potential of question asking, benefits of immediate responses during in class instruction, and potential of tracking students' progress.

Background

Students need multiple opportunities to receive feedback on their current understanding. We have been experimenting with a commercially available classroom communications system (CCS) called the Personal Response System (PRS)(Avantec, Educue [1]) to assess students' thinking during class. Using the PRS, the instructor can pose a multiple-choice question and the students can respond with a small infrared transmitter. Students' responses are aggregated immediately and can be displayed in the form of a histogram. The authors and other colleagues in VaNTH find the system very helpful at engaging students in the classroom, and it provides valuable feedback on what students currently understand about the ideas presented. Students have found this very helpful to have this feedback during class along with follow-up discussion with their peers and the professor's explanation [2].

Technology for this functionality has evolved over the past decade. One of the earliest systems is Classtalk, consisting of small palmtop computers or calculators (Texas Instruments and Hewlet Packard) connected to the teacher's computer with cables at each seat [3,4,5]. Recently, Texas Instruments rolled out a system called Navigator, which uses wireless hubs located strategically throughout a classroom. Students connect to the hub through their TI calculator. This works well in many engineering schools where the calculator is a ubiquitous device. Other manufactures use infrared (IR) technology to provide wireless connectivity with the instructor's computer.

The VaNTH ERC has created their own version of a CCS to leverage the wireless laptop technology students are using as part of the laptop initiative at Vanderbilt. One of our strongest motivations for this project is to explore the value added by including short answer and essay capabilities to the classroom communication system. A prototype system called VaNTH Student Assessment System (VSAS) has been developed, and was tested during the Fall of 2002 as part of a freshman seminar course on biooptics. The follow describes the system and a brief example that illustrates some of the system's benefits for classroom instruction.

VaNTH Student Assessment System (VSAS)

VSAS is one solution that takes advantage of wireless networking infrastructure becoming standard in many schools and universities. The software is composed of three major components, a SERVER program, a TEACHER program and a STUDENT program. A central server hosts multiple sessions of VSAS, managing communication between TEACHER and STUDENT components. Currently, the TEACHER program runs locally on a teacher's workstations (either a desktop or laptop computer) and is used to access and pose questions to students, aggregate results, display results and store students records into an external file. Before class a teacher uses either the VSAS program or a word processor to construct a series of questions to pose during a class session. At the beginning of class the instructor starts a session on the server and the students log into this session using their browser. A small applet window is opened which initiates the STUDENT program. Then in class the teacher can select one of the questions in the TEACHER program and send it to the students' laptop. When the questions appear on the students' laptop, they can respond and submit their response. When the TEACHER program receives all the students' responses it aggregates and stores the results on the server. These results can be accessed immediately in class. Multiple-choice answers are displayed as a histogram showing the percentage of students who selected each response. Short answer responses are displayed as a list, with one line for each student. Essay answers are stored and accessed later by the instructor.

The second major component of VSAS is the STUDENT program, which is a java applet that allows students to link with the TEACHER program as part of a class session. Students run this applet from any device that can run a java applet, including laptops with wireless capability, desktop machines in computer labs, or a growing number of handheld devices that support java and wireless connectivity. When the teacher selects a question and sends it to the students, the STUDENT program displays the questions in a window with an appropriate input method for the question type. For example, a multiple choice question uses a pull down selection mechanism, short answer has a one-line field and essay type questions have a larger, multiline input field. The interface allows students to rate their confidence in their response using a low, medium or high scale.

Method

The initial goals for our use of VSAS were to replicate the use of CCS using multiple-choice questions and to explore the capabilities and uses for the short answer and essay answers. In addition, we wanted to evaluate the robustness of this technology for use in the classroom. The VSAS was used periodically throughout the semester in an optional 1-credit freshman seminar on biooptics with 18 students (see [6], in this volume for more details about the course). Several classes were observed by outside researchers and a survey was used to measure students' perceptions of the system at the end of the course.

The VSAS system was used in several ways, depending on the specific goals for a particular class session. The instructor used multiple-choice questions to access students' initial thoughts related concepts about to be taught. These questions are designed to challenge students' intuitions that are often flawed when based on general observations. Good questions often result in semi-normal distribution of responses. This illustrates to both the students and instructor that only a few students are familiar with the concept, and many are just guessing. This provides an excellent teachable moment to discuss as a class the various options, or use a demonstration and/or lecture to explore the underlying principles that influence the answer to a question.

Multiple-choice questions are also used to test students' understanding of specific concepts immediately follows class activities designed to teach these concepts. The immediate feedback provides students and the instructor with some indication of the level understanding of the class. Students who don't quite understand may see that they are not alone, and realize where their misconceptions or gaps in knowledge lie.

Short answer questions require students to generate their own response, rather than recall it from a list of options. The instructor designed questions requiring students to list a casual chain of events, or to simply provide a term. This feature has a range of possibilities and depends on content and specific learning goals. Two applications of the system were observed to document use of free-text responses. The first case was a post quiz to a short lecture on the anatomy of the eye. The second application of short answer questions asked students to reflect on what students learned from a field trip to a laser clinic. This reflection activity served as a pre-test for a lecture. After the lecture the students answered the questions again. (Details of these questions are mentioned in the next section).

Essay questions were mainly used to capture students' questions at the end of a class session. A common technique called "Muddiest Points" typically asks students to write down what is still difficult for them to understand after the class session. With VSAS this activity is much faster and easier for students, and we believe results in higher response rates. The instructor reviewed these responses after each class and made a specific point to refer to them in the follow on class sessions.

Results and Discussion

The instructor had great success experimenting with the short answer feature of VSAS. One of the perceived benefits of the short answer response versus the multiple choice is that students must generate a response rather than picking a potential response from a list of options. We believe this process requires students to retrieve information in a way similar to the way they will need to access information in the future. Also, asking students about their initial intuitions before a lecture can help prime them to focus on important issues during the class session. For example, as part of the one class session, the instructor gave a short lecture on the anatomy of the eye, then asked students to create an ordered list of the sequence of parts of the eye that light travels through before the nerves sense the presence of light. Students provided a range of answers to these questions. Some students only listed two or three parts of the eye. Others had more detailed lists, but incorrectly ordered. The professor was able to display this list of answers anonymously using a projector connected to the laptop that was running the TEACHER program. In this situation the instructor chose to synthesize the list for the students. He started down the list and described what was correct or missing from the list. During this review, many students spontaneously ask clarifying questions, while previously they had been relatively quiet. This response is similar to that observed in other classrooms using the PRS. Students appear much more willing to ask questions, either because the process stimulate questions for them when previous instruction did not, or students are more at ease because they feel invited to ask. An alternative instructional approach would focus on students trying to synthesize the list of answers provided by their peers. With the instructor's guidance they could create a single comprehensive list. This may take more time, and may not be appropriate for certain learning objectives. However, in some situations this activity can help students practice sorting and prioritizing of critical factors that they will need to be able to differentiate in future problem solving situations.

In another example, the class had recently visited a laser clinic to observe a new type of laser instrument. At the next class session the instructor planned a lecture to explain the physics associated with this laser. Prior to the lecture the instructor posed several questions including -

1. While visiting the laser clinic we saw the VISX ArF excimer laser which is used for the surface ablation to remove tissue to correct the corneal shape. We also saw the new flap cutter laser (the Intralase fs) which is a very different type of laser and interacts with tissue very differently. Briefly describe your understanding of how the flap cutter laser works and does its job.

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2. What wavelength (or in what part of the spectrum) does the flap cutter laser operate?

3. Is the wavelength of the flapcutter laser absorbed well?
   a) strongly absorbed
   b) somewhat absorbed
   c) very weakly absorbed

4. Based on the answer to the previous question (this wavelength is almost not at all absorbed) how can the laser still succeed in cutting the flap?

After the lecture students were asked the same questions again, and performed much better, providing clearer and more accurate descriptions. Also, recall of facts such as wavelength also was increased. This illustrates that the laboratory visit provided an orientation for much of the information, helping raise students' awareness. The lecture had a strong impact on their ability to answer the questions. The combination of the field trip, the reflection activity using VSAS, and the lecture provide a powerful learning opportunity for students.

VSAS is currently in the prototype stage of development, and initial use identified several technical issues. The login process was somewhat difficult for students, and occasionally student connections were broken due to their laptops going to "sleep" or transient loss of wireless connectivity for other reasons. However, after initial attempts, students could log on easily and recognize certain situations requiring them to follow a simple procedure to re-establish their session. In addition, the number of connected students displayed by the TEACHER program was occasionally wrong. These difficulties did not substantially affect the instructor or students' ability to successfully use the system.

Conclusion

VSAS provides a useful enhancement to classroom dynamics that can improve students understanding of biooptics concepts. Use of VSAS in this freshman seminar provided multiple opportunities for students to display their current level of understanding about various concepts. The report of their responses provides an excellent artifact for discussion in the classroom, and can be used by the instructor to identify what students currently know as well as diagnose areas where students need clarification. As such, the instructor can tailor their teaching strategies to better match student understanding. The short answer responses require students to generate a response to a question, requiring a higher cognitive demand compared to the recognition process for multiple-choice selection. Embedded assessment activities like VSAS are an important element in tracking students' progress toward specific learning objectives. With the short answer and essay questions an instructor can assess more advanced skills like students' ability to explain, predict and analyze the application of fundamental concepts for a course.

VSAS is a natural addition to any organization with the infrastructure to provide every student with a networked web browser. Many institutions are incorporating laptops and wireless networks for use by students and instructors during classroom sessions. Other response systems are commercially available, but require the use of propriety hardware and software, which increases the cost per student to use the system. In addition, these systems only provide a multiple-choice response from the students. VSAS adds the capability to make students more generative in their response through short answers and essay formats. We are currently seeking resources to further develop the system. Following several enhancements related to reliability and ease-of-use, other institutions with appropriate infrastructure could begin using VSAS to enhance their classrooms.

Acknowledgements

This work was supported primarily by the Engineering Research Center Program of the National Science Foundation under Award Number EEC9876363

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Biography

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