AC 2007-2519: USING INKSURVEY: A FREE WEB-BASED TOOL FOR OPEN-ENDED QUESTIONING TO PROMOTE ACTIVE LEARNING AND REAL-TIME FORMATIVE ASSESSMENT OF TABLET PC-EQUIPPED ENGINEERING STUDENTS

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Using *InkSurvey*:
A Free Web-Based Tool for Open-Ended Questioning to Promote Active Learning and Real-Time Formative Assessment of Tablet PC-Equipped Engineering Students

Abstract

Vast amounts of educational and psychological research support the efficacy of both active learning and frequent real-time formative assessment in improving learning. Educators are now discovering that technology can greatly assist them in these realms as they strive to improve the learning experiences they deliver. We describe *InkSurvey*, a web-based tool we have developed specifically to allow an instructor to pose open-ended questions to students during class. Students use Tablet PCs to respond to these questions with their own words/sentences/paragraphs entered manually via the keyboard, or with digital ink that allows handwriting, sketches, equations, graphs, derivations, etc. Confidence level can be included if desired. The instructor receives an instantaneous compilation of web-based student responses.

These open-ended questions can closely approximate the types of problems engineering students will soon face on the job; the possible formats for their responses also reflect what they will encounter in the workplace environment. The real-time formative assessment provided by this use of technology aids student metacognition and helps the instructor address misconceptions during the "teachable moments" that frequently occur when the *InkSurvey* tool is used.

We provide details of how instructors from any campus can incorporate the use of this *InkSurvey* tool into their instructional program. In cooperative learning situations, one Tablet PC can be shared within each small group of students, thus reducing hardware requirements. This tool is also useful in facilitating differentiated learning and Just in Time Teaching (JiTT) techniques.

In order to use the *InkSurvey* tool, Tablet PCs must have internet connectivity and have the Firefox browser installed. There is no additional software required and there is no cost to other institutions for the use of this tool.

Introduction

The past three or four decades have seen unparalleled advances in our understanding of the mind and learning.[1] These new theoretical insights are now guiding significant changes in the way teachers teach, at engineering institutions as well as elsewhere. Many contemporary efforts to enhance learning are based on the constructivist theory of knowledge, that one builds new knowledge and understanding based on previously learned concepts and facts, within the context of social interaction and agreement.

At this same moment in time, educators also are exploring how new technology, such as Tablet PCs, can help facilitate changes driven by these theoretical underpinnings. In particular, we are interested in using Tablet PC technology to encourage active learning (interactive engagement) and probe student understanding through frequent formative assessment. Not only are both

active learning and frequent formative assessment in keeping with the constructivist theory of learning, they are both broadly supported by educational research.[2, 3]

Simpler technology can promote these same goals, and we have seen rapid, widespread, and enthusiastic dissemination of classroom communication devices ("clickers") across the country.[4] However, their limitations to multiple-choice and short numerical responses pose challenges in probing higher-order thinking skills in the classroom. To move beyond these limitations, a variety of Tablet PC-compatible tools are being used to facilitate communication within the classroom, such as *Classroom Presenter*,[5, 6] *Ubiquitous Presenter*,[7] and *DyKnow*.[8, 9] We have developed *InkSurvey*, a simple, easy-to-use, and robust web-based communication tool. It allows an instructor to pose open-ended questions to students during class and receive real-time student responses that can include words, graphs, equations, derivations, sketches, etc. *InkSurvey* is a pedagogical tool designed to facilitate communication in classrooms where the instructor and every student or group of students have access to a Tablet PC.
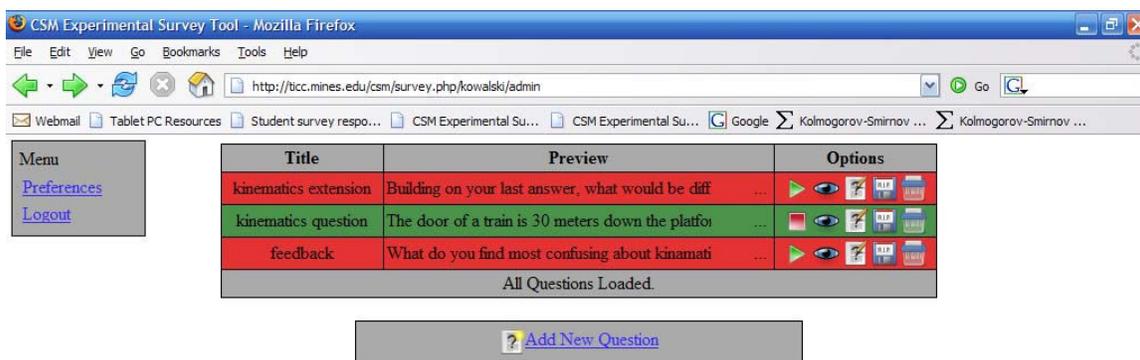
Description of *InkSurvey*

Before the class meeting, the instructor enters the questions for that day on his/her *InkSurvey* webpage. Various formats of questions are possible; certain situations may make questions other than open-ended more appropriate. For the purpose of this discussion, we follow the steps for an open-ended kinematics question, as entered in Figure 1.

Figure 1: Entering an open-ended question.
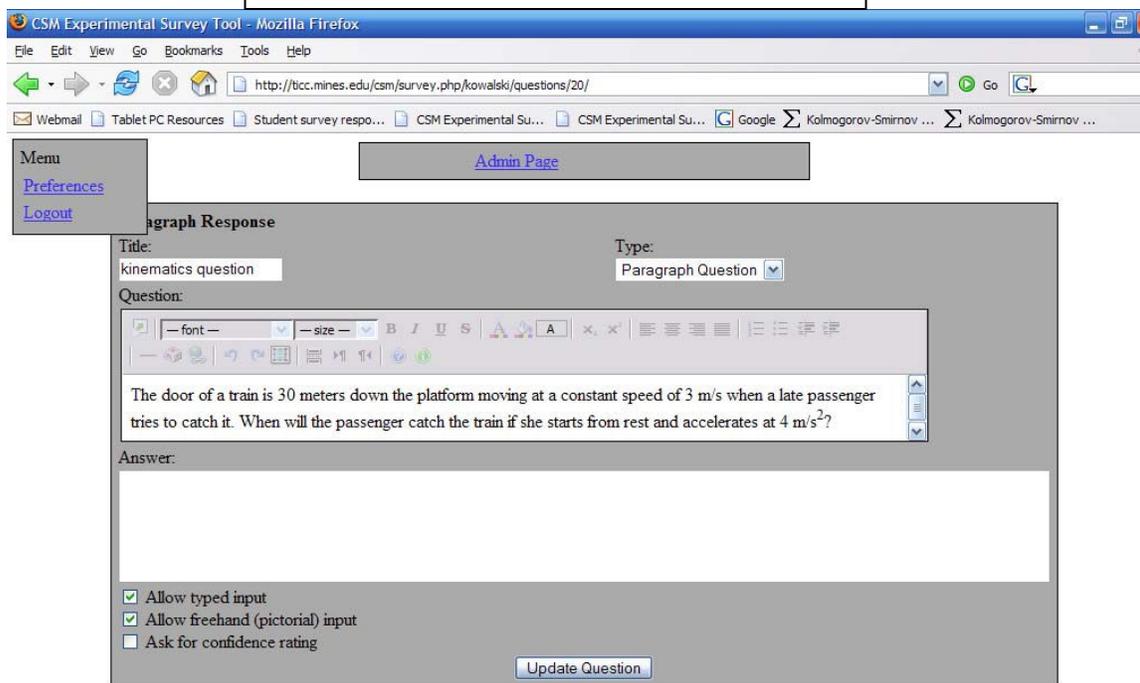
After each question has been entered, the instructor sees a preview screen such as that in Figure 2. This provides an opportunity for editing as well as a chance to add more questions. Looking at the "options" to the right of each question listed, one sees a series of icons. The first (leftmost) is used to activate a question, or make it available to students to see and enter input. When this is chosen, the question listing becomes green so that one can tell with a quick glance which question is activated. It is possible to activate any number of questions at one time, which gives the students more freedom to work at their own pace. This feature is also useful when soliciting student responses before the class meeting (JiTT) and for facilitating differentiated learning. The second icon allows the instructor to view student responses. This is used for real-time feedback during class; refreshing with this button updates the instructor view to include all responses submitted to that point. This icon is also used to access responses at a later time (stored data). The third icon (the question mark) allows the instructor to edit the question; the fourth allows tombstoning the question for later retrieval, and the fifth permanently deletes the question.

Figure 2: *InkSurvey* instructor's page, listing all questions which have been entered thus far.

We have found class time goes more smoothly if all questions are entered before class; since the questions will be selectively activated during class, it is possible to enter more questions on a given concept than one thinks will be used. In this way, if the real-time feedback indicates poor student mastery of the concept, the instructor can take advantage of the "teachable moment" and

then seamlessly follow-up with additional questions to assess revised student understanding. However, it is also possible to enter the questions "on-the-fly" during class.

When the instructor is ready to pose one of the questions in class, he/she opens the *InkSurvey* instructor's page to activate the particular question desired. Following our example with the kinematics question entered, the instructor would choose to activate it. Students need to open the Firefox browser and go to their student page, where they will see the questions that have been activated. Choosing the kinematics question yields the webpage shown in Figure 3.

Figure 3: Student page, after student has indicated he/she wishes to respond to the activated kinematics question
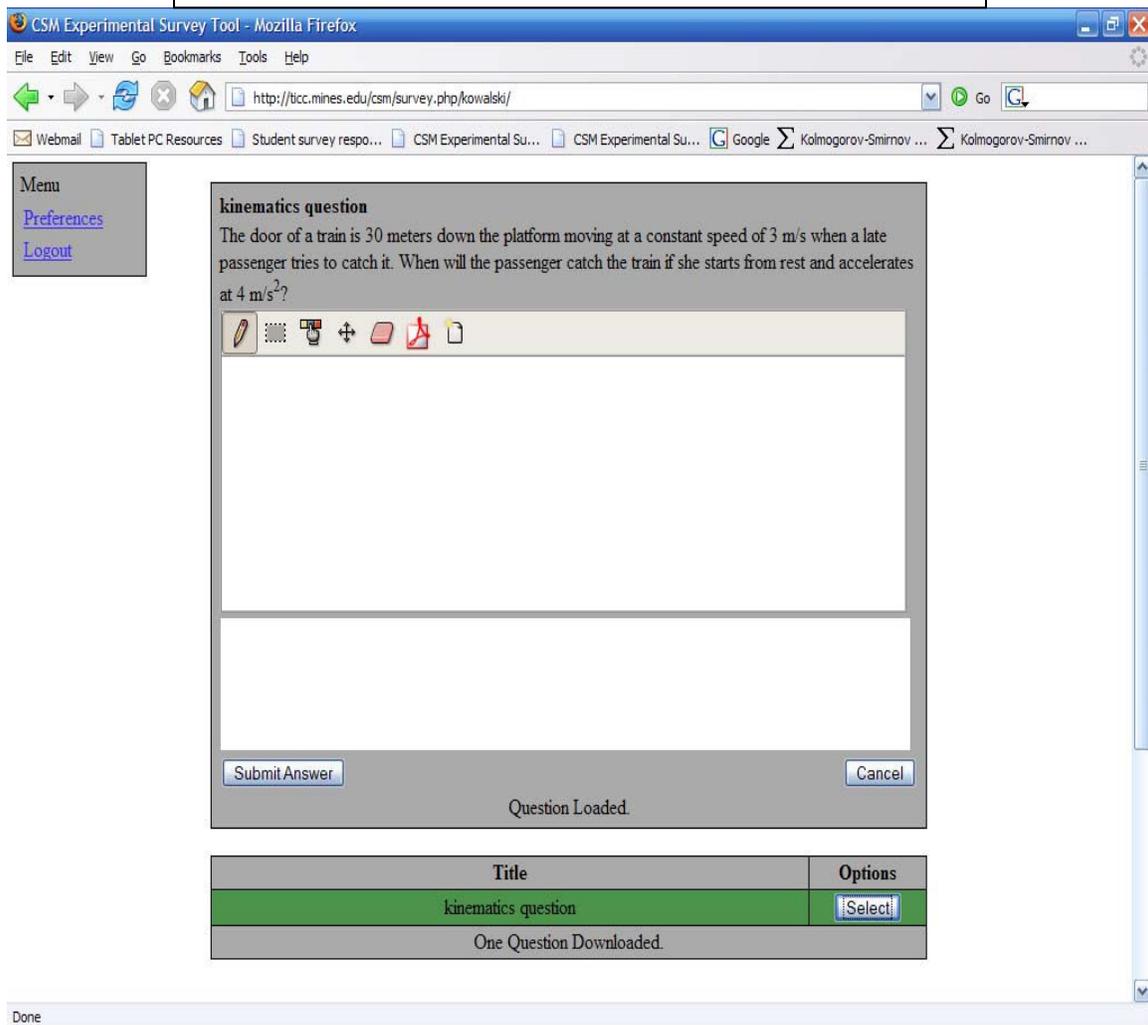
Now, students can enter their responses using words (either typed or pen-based), graphs, equations, derivations, sketches, etc. If the instructor would like the student responses to be non-anonymous, students can be asked to place identifiers on the responses they submit. In Figure 4, student #12 has chosen to approach the solution to this problem graphically.

Figure 4: Student page, showing a freehand solution in progress. Once the solution is completed, student #12 then taps "Submit Answer" with the pen.
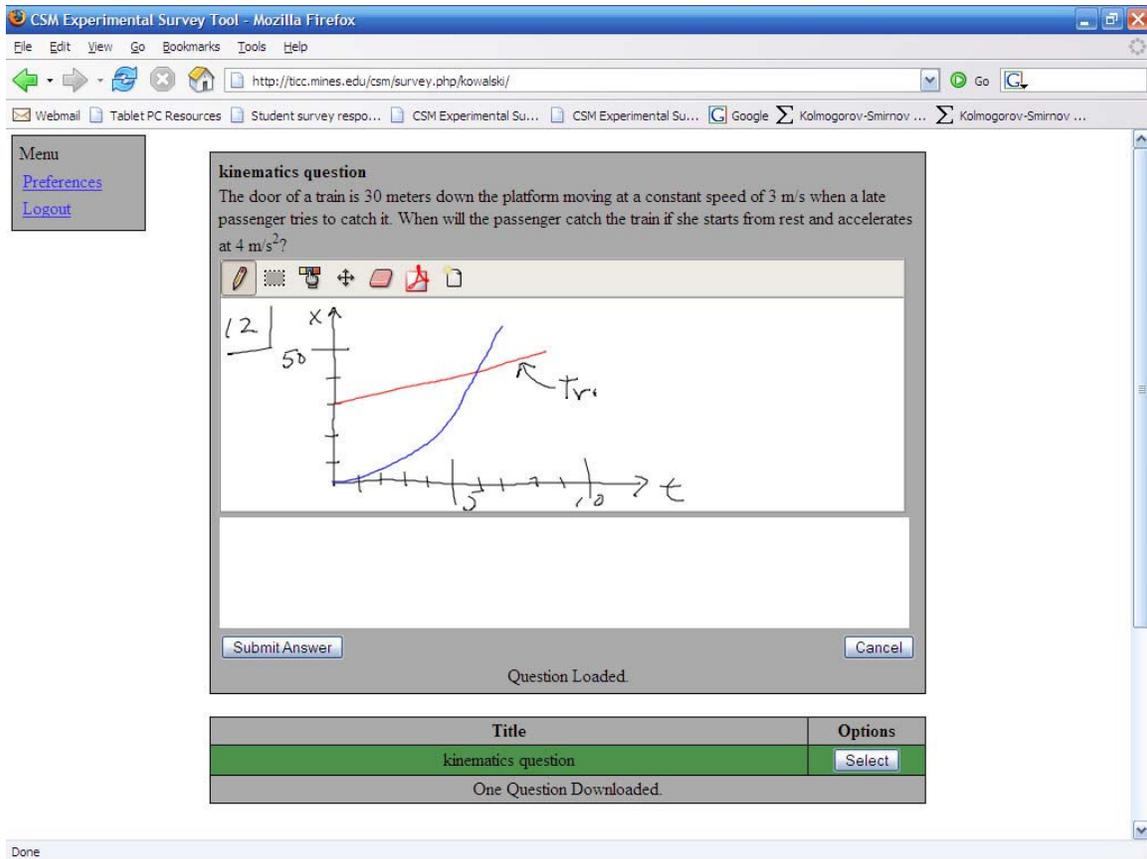
The students' preparation of these responses demands a very high level of active learning and engagement with the material being discussed. It also helps students learn to recognize when they understand and when they need more information ("metacognition").

InkSurvey is well suited for supporting collaborative work, particularly if there are not enough tablets to equip students individually. Also, since there is no limit to how many responses can be submitted per student or per tablet, multiple students can enter their responses using one Tablet PC.

As the students are entering their responses, the instructor can select "view responses," which refreshes the instructor page to reveal all student feedback submitted up to that moment. This has proved to be advantageous since it buys the instructor additional time to assess student understanding and prepare a thoughtful response. Also, if the instructor notices that many students are demonstrating the same misconception, he/she can make comments to realign student thinking and students can prepare altered responses immediately. In Figure 5, the

instructor has received one response submitted in text (from student #9, seeking clarification about the problem) as well as a completed solution in digital ink from student #12.

Figure 5: Instructor page, showing real-time feedback from students #9 (response in text) and #12 (freehand response).
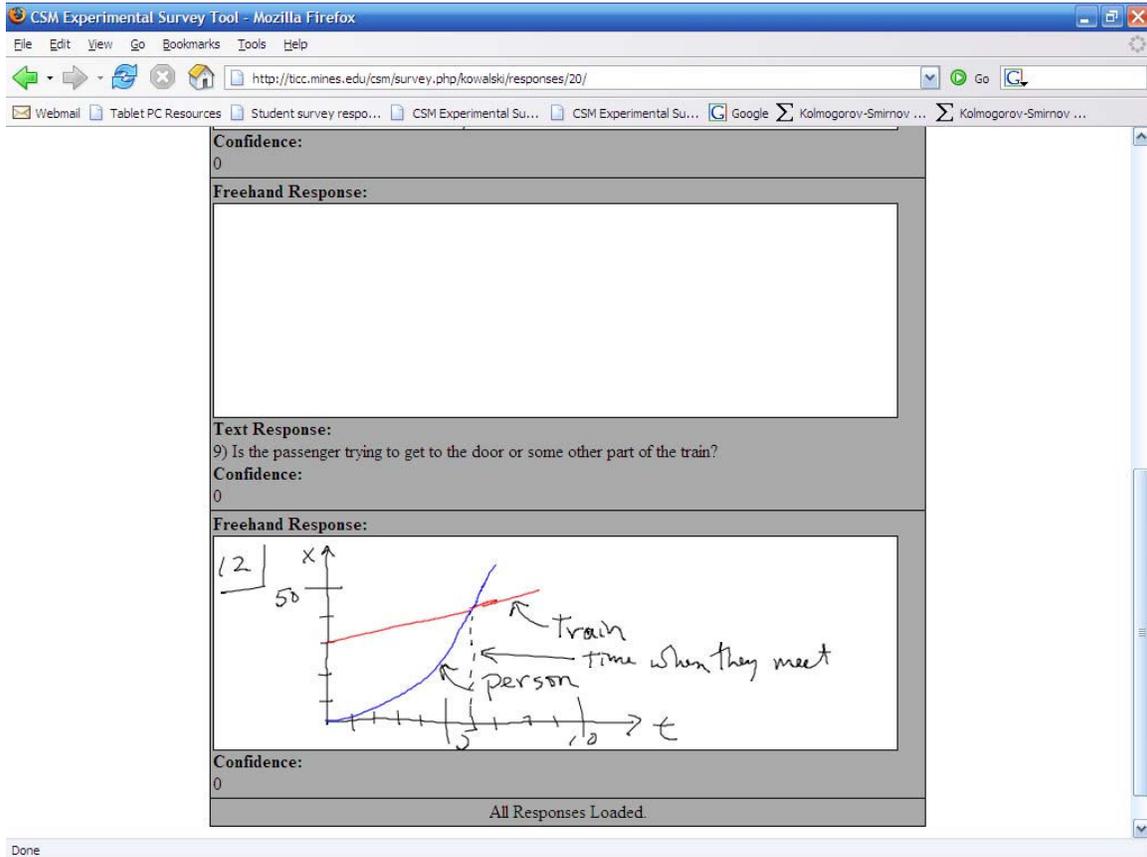

Soon, other students have transmitted their solutions, and by scrolling down, the instructor can quickly see this real-time feedback. In Figure 6, two additional responses have been received.

During the ensuing "teachable moments" that follow the collection of the real-time feedback, the instructor can help the students to further refine, modify, validate, or enhance their understanding. At the discretion of the instructor, selected student responses can be shared with the class in general.

All student responses are automatically saved on the instructor's web page until the instructor chooses to purge them. However, we cannot guarantee how long they will remain on our server; instructors may wish to save these responses in their own space, to provide a record of the responses.

Figure 6: Additional responses have been received from students #8 and #13.
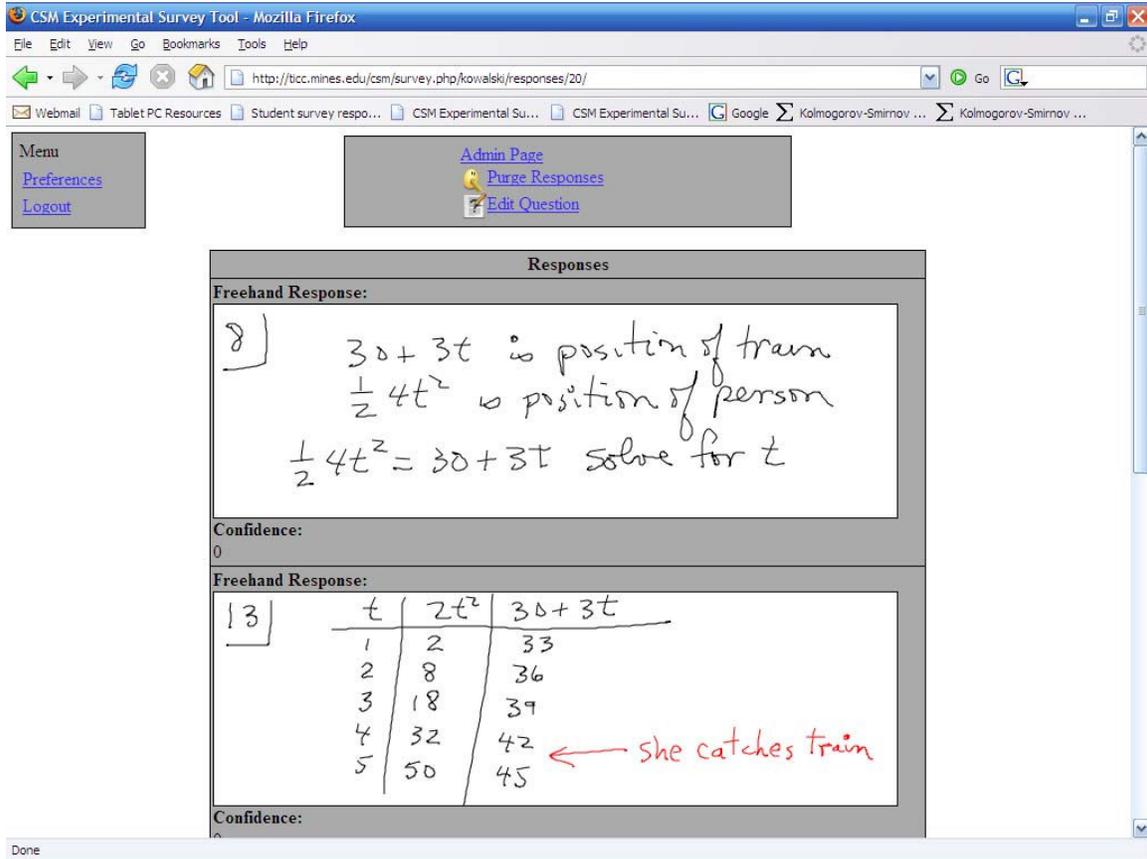
With any type of question, it is possible to ask students to include a confidence level if desired—that is, an indication of how certain they are of their responses. This feature refines metacognition and also provides valuable information to the instructor.

If the question posed is in the fill-in-the-blank/short answer format, *InkSurvey* will sort the responses based on similarity to key words the instructor enters when composing the correct answer to the question. In the instructor's view of the responses shown in Figure 7, the graphical display reveals both the confidence level and the "correctness" ranking of the responses.

In order to take full advantage of the Tablet PC's pen-based technology, *InkSurvey* is designed for use with the free Firefox browser. Using other browsers (Netscape or Internet Explorer), all features are fully functional, except those that rely on the pen.

Figure 7: Instructor's page showing sorted responses to a short-answer question.
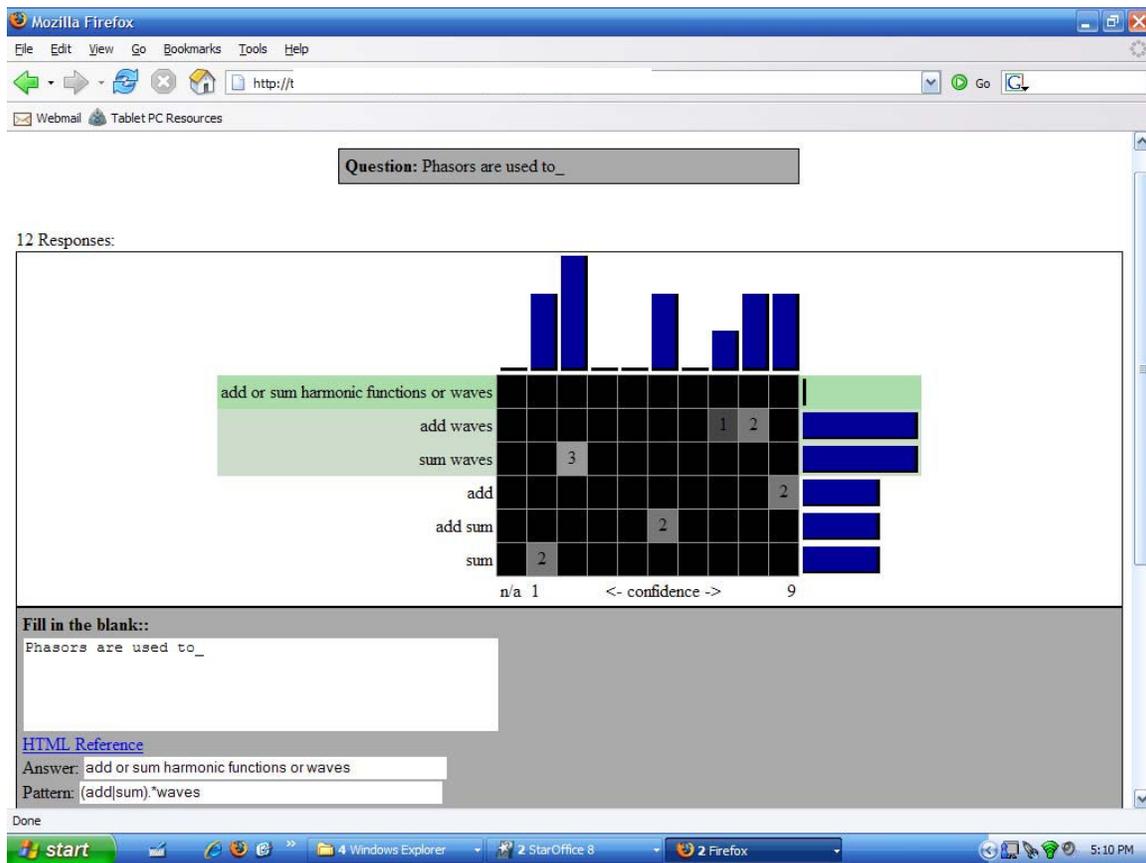
Advantages of the *InkSurvey* tool

As with other classroom communication technology, the *InkSurvey* tool facilitates both active learning and real-time formative assessment in the classroom. As students interact with the topics being studied, teachers reveal and address misconceptions and incomplete understandings, then help each student build on correct ideas to achieve a more mature understanding. By frequently monitoring students' changing conceptions and providing meaningful and timely feedback as instruction proceeds, instructors using this tool vigorously promote student metacognition.

InkSurvey is also designed to allow for differentiated learning. A sequence of questions can be simultaneously activated for the students, enabling all students to respond to a basic question and those students who have mastered the concept at this level to continue to another, more sophisticated question. This feature is also appropriate for student input to multiple questions for JiTT ("Just in Time Teaching") before class meetings.

The compelling reason for the development of *InkSurvey* was our desire to probe student understanding with open-ended questions, rather than multiple-choice or short numeric

questions. We have found these open-ended questions more advantageous for multiple reasons, including:

- We feel open-ended questions increase the validity of the real-time formative assessment. Since students do not have a list of answers from which to choose, guessing is much more difficult. Also, the use of open-ended questions eliminates the need for the instructor to construct probable distractors for a multiple-choice question—an especially difficult task for novice instructors or those teaching a course for the first time.
- The frequent use of open-ended questions forces both instructors and students to think about learning objectives of the class and how students will demonstrate their mastery of those objectives. Furthermore, the open-ended questions provide an opportunity for students to practice demonstrating their learning to the instructor before the exam setting.
- These open-ended questions more closely approximate the type of problems engineering students will soon face on the job; the possible formats for their responses also reflect what they will encounter in the workplace environment. As a result, the use of open-ended questions better emulates how students perform out on the job.
- Formulating an original, written response provides students with an opportunity to improve their critical thinking skills through writing. Emig contends that "Writing represents a unique mode of learning"[10] and when students write about content, they understand it better and remember it longer. This connection between writing and successful learning strategies has served as the basis of widespread educational reform movements such Writing Across the Curriculum, Writing to Learn, Writing in the Disciplines, and others. These reforms have positively impacted engineering education across the country, including at our institution.[11] Furthermore, this writing helps students attain an ability to communicate effectively, which is ABET's Criterion 3(g) for Accrediting Engineering Programs.[12]
- With the pen-based technology of the Tablet PC, student responses can be in words, graphs, equations, derivations, etc. These responses can reveal a great deal to both the instructor and the students about student understanding.
- With open-ended questions, it is much easier to assess higher level thinking skills in the students.

The *InkSurvey* tool is free and simple to use. We have successfully tested its use with over 60 student Tablet PCs at one time. Overall, student response has been enthusiastically favorable. Comments on student surveys reveal that students appreciate being able to so easily and accurately provide real-time feedback about their understanding to the instructor; they also find the active learning situation both stimulating and helpful. Elsewhere, we discuss the challenges faced by students and instructors transitioning from multiple-choice (clicker) to open-ended questions for real-time formative assessment.[13]

How to Access the *InkSurvey* Tool

In order to use the *InkSurvey* tool, Tablet PCs must have active internet connectivity and have the Firefox browser installed (free download at http://mozilla.com/firefox/). There is no additional software required since *InkSurvey* is entirely web-based and there is no cost to other institutions for the use of this tool. Instructors wishing to use *InkSurvey* in their teaching should visit the registration site at http://ticc.mines.edu/csm/survey.php/newlogin/.

Conclusions

We have developed *InkSurvey*, a pedagogical tool that enables active learning and real-time formative assessment in classrooms with Tablet PC-equipped students. This web-based tool allows instructors to ask open-ended questions and the students may respond with words, sketches, equations, graphs, derivations, etc. The instructor receives real-time feedback through these responses.

We feel these open-ended questions can closely approximate the type of problems engineering students will face on the job. Although we describe *InkSurvey*'s usage at an engineering university, this paradigm is broadly applicable and we make the tool available for free to all educators.

Acknowledgements

Bibliography

1. Bransford, J.D., Brown, A.L., & Cocking, R.R. (eds.) (1999). "How people learn: brain, mind, experience, and school." Washington DC: National Academy Press.
2. Hake, R.R. (1998). "Interactive engagement vs. traditional methods: A six thousand student survey of mechanics test data for introductory physics courses." *American Journal of Physics*, **66**, 64-74.
3. Black, P. and Wiliam, D. (1998). "Inside the black box: Raising standards through classroom assessment*." Phi Delta Kappan*, Nov.1998. Accessed online at http://www.pdkintl.org/kappan/kbla9810.htr.
4. Duncan, D. (2005). "Clickers in the Classroom." San Francisco CA: Pearson Education, Inc.
5. for a list of publications by Richard Anderson *et al.* regarding Classroom Presenter, please see http://www.cs.washington.edu/education/dl/presenter/papers.html.
6. Koile, K. & Singer, D. (2006). "Improving Learning in CS1 with Tablet-PC-based In-Class Assessment." ICER 2006 (Second International Computing Education Research Workshop). Available online at icampus.mit.edu/projects/Publications/CLP/KoileSinger2.pdf.
7. Wilkerson, M., Griswold, W.G., & Simon, B. (2005). "Ubiquitous Presenter: Increasing Student Access and Control in a Digital Lecturing Environment." SIGCSE Technical Symposium on Computer Science Education.
8. Berque, D. (2006). "An evaluation of a broad deployment of DyKnow software to support note taking and interaction using pen-based computers*." Journal of Computing Sciences in Colleges*, **21**: 6, 204-216. Available online at http://people.depauw.edu/dberque/ccsc_ne_2006_berque.pdf.
9. Enriquez, A.G., Gunawardena, A., Kowalski, F., Kowalski, S., Millard, D.L., & Vanides, J. (2006). "Innovations in Engineering Education Using Tablet PCs – Panel Discussion with Four Institutions," 2006 Frontiers in Education Conference. Available online at http://fie.engrng.pitt.edu/fie2006/papers/1248.pdf.

10. Emig, J. (1977). "Writing as a mode of learning," College Composition and Communication **28**, 122-128.

11. Olds, B.M. (1998). "Technical writing across the curriculum: process, problems, and progress," 1998 Frontiers in Education Conference, Tempe, AZ. Available online at http://fie.engrng.pitt.edu/fie98/papers/1359.pdf.

12. ABET Engineering Accreditation Commission (2006). "2007-2008 Criteria for accrediting engineering programs." Baltimore, MD: ABET. Accessed online at http://www.abet.org/Linked%20Documents-UPDATE/Criteria%20and%20PP/E001%2007-08%20EAC%20Criteria%2011-15-06.pdf.

13. Kowalski, F. & Kowalski, S. (2007). "Understanding and Overcoming Student-Based Difficulties when Transitioning from Multiple-Choice (Clicker) to Open-Ended Questions for Real-Time Formative Assessment." 2007 ASEE Conference, Honolulu, HI.