AC 2007-2643: UNDERSTANDING AND OVERCOMING STUDENT-BASED DIFFICULTIES WHEN TRANSITIONING FROM MULTIPLE-CHOICE (CLICKER) TO OPEN-ENDED QUESTIONS FOR REAL-TIME FORMATIVE ASSESSMENT

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Understanding and Overcoming Student-Based Difficulties when Transitioning from Multiple-Choice (Clicker) to Open-Ended Questions for Real-Time Formative Assessment

Abstract

The utilization of Tablet PC technology to facilitate open-ended questioning for real-time formative assessment is a very powerful pedagogical tool. We describe the challenges our students faced as we transitioned from multiple-choice (clicker) to open-ended questions for real-time formative assessment in two upper-level engineering physics courses. These difficulties were of three main types: increased student stress, more obvious differences in rates and levels of student learning, and distractions from the technology. We believe an awareness of these difficulties will help others who try to replace multiple-choice questions with open-ended responses in their classes. Furthermore, we have developed and described some useful strategies for overcoming these challenges.

Background

In recent years, educators have enthusiastically embraced the use of individual student response devices (“clickers”) to incorporate more active learning into the higher education setting. Relatively inexpensive and easy to use, these classroom communication devices allow for individual student metacognition and real-time formative assessment even in very large classes. Much anecdotal evidence and a growing body of emerging data indicate that the use of this technology and the pedagogical shifts that accompany its use improve student learning.\(^1\)\(^-\)\(^3\)

In basic models of classroom communicators, however, student responses are limited to the selection of choices presented in multiple-choice questions or, in some cases, brief numerical responses. Like many other campuses worldwide, on our campus clickers are used with great effectiveness in introductory-level courses, including the first three semesters of the engineering physics sequence. However, we hear of the frustrations of faculty members who find it difficult to probe higher-level thinking skills using the multiple-choice format. Furthermore, some wonder if these types of questions adequately prepare students for their post-graduation experiences in the field of engineering physics.

To move beyond such limitations of multiple-choice questions, we turned to the emerging pedagogical potential of Tablet PCs.\(^4\)\(^,\)\(^5\) We developed a web-based tool (InkSurvey) that allows students to use Tablet PCs to transmit open-ended responses created with words, sentences, or paragraphs entered manually via the keyboard, or with digital ink that allows handwriting, sketches, equations, graphs, derivations, etc. Elsewhere, we describe the advantages of this free pedagogical tool and how other educators can access it for their own classrooms.\(^6\) We have used the InkSurvey tool in nearly every class meeting for two courses: PHGN 361 Intermediate Electromagnetism (Spring 2006, 62 students) and PHGN 462 Electromagnetic Waves and Optical Physics (Summer 2006, 22 students).
While this pedagogical application of technology effectively facilitates real-time formative assessment yet overcomes the shortcomings inherent in multiple-choice questions, we have found some unanticipated student-based difficulties. Other instructors who are transitioning from posing multiple-choice questions to posing open-ended questions for real-time formative assessment may benefit from an awareness of the difficulties that faced our students.

**Difficulties our students encountered**

Our understanding of the student perspective has been guided and informed by anonymous student surveys administered at the end of each semester (84 students total) and numerous student focus group discussions throughout both semesters.

In comparison with teaching/learning experiences based on clickers, we noted these clear trends when the open-ended questions were used:

1. **Increased levels of student stress.** The first problem we encountered was greatly increased stress levels experienced by the students, as reported in the student focus group discussions. Compared with the traditional lecture setting, this pedagogical model is much more demanding of students and requires that they “perform” frequently during the class meeting. Furthermore, the level of active learning required is very high. For example, in their previous classes, students might have been asked a multiple-choice question that required them to use a particular equation to solve a problem and recognize the correct answer from the choices provided. In contrast, with open-ended responses they were more likely to be asked to solve the problem (no choices given), or to explain in words how they would solve the problem, or to derive the equation, etc. Their understanding was probed much more extensively and guessing was no longer an easy option. Although we view this as a robust pedagogical advantage, we hadn’t initially anticipated the resulting increased level of stress experienced by the students and had made no efforts to address it.

2. **Greater differences in rate at which students work on questions posed.** When using this method to teach, the instructor becomes more acutely aware of different rates of task completion as well as different levels of comprehension among students. We believe several factors contribute to this difference, including the depth of student understanding probed, the lack of the guessing option, and genuine differences in the rates at which students solve more complex problems (perhaps the more complex the problem, the greater the spread in solution times). This clearly presents difficulties in classroom management: how should instructors handle the students who submit responses much earlier or later than the majority of their peers? This difference in the rate of student task completion presents itself in other contexts in the academic environment, but it is particularly conspicuous here.

3. **Increased temptations** related to on- and off-task instant messaging, playing games, and off-task internet surfing. One problem encountered (which we had anticipated) was the temptation for students of off-task internet surfing. Unexpected, however, was the issue of instant messaging. During the class time dedicated to students responding to the questions posed by the instructor, we discovered that there was a certain amount of collaboration occurring among the students via instant messaging.
At the end of the summer semester, we asked students to estimate what percentage of class time they spent using the Tablet PC for activities not related to classwork (e.g., instant messaging, surfing, playing games, or checking e-mail). The average response was 15%. However, the considerable individual variation among these multi-taskers is revealed by a standard deviation of 14% (sample size of 22).

**Overcoming student difficulties**

We have encountered these difficulties in our earliest efforts at implementing this pedagogical model in the classroom, and although we doubt that any of the challenges have been completely eliminated, we feel that we have made significant progress toward alleviating them.

1. Increased levels of student stress. Although using the content of the student responses as a factor in the student grade ensures maximum student effort, it puts an enormous stress on the students. Instead, we gave credit for thoughtful participation in class via student responses. Simply assuring the students that 5% of their course grade would be determined by how often they submitted thoughtful class responses seemed to be a sufficient motivating factor to maintain a high quality of responses without causing undue anxiety.

Student stress levels were further lowered when we discussed our goals of enhancing their learning experiences by using these open-ended questions for real-time formative assessment and improved metacognition. This parallels a point made by Duncan regarding the use of clickers in the classroom: it is critical to explain to the students why the technology is being used and what they will gain from its use. These particular students had already experienced first-hand (for three semesters) the advantages afforded by the use of clickers in the classroom. Additionally, we pointed out in class the advantages of the open-ended questions (vs. multiple-choice questions), such as better emulating situations they will encounter in the workplace.

Moreover, students were encouraged to use the open-ended questions as a vehicle for asking the instructor their own questions when they couldn’t solve a problem. If they didn’t know how to solve a problem posed for the clickers, most students would just guess and neither they nor the instructor would gain much useful information. However, when they didn’t know how to solve an open-ended question, we often received responses which told what they knew and then either asked for a hint on how to proceed or requested some clarification to get them over a stumbling point. Since the instructor can frequently refresh the webpage that shows the student responses, he/she can monitor the responses submitted and provide immediate feedback to help students modify their misconceptions. Students can then amend their responses to reflect their new understandings.

2. Greater differences in rate at which students work on questions posed. Addressing this difficulty actually opened the door to introducing more differentiated learning experiences in larger-enrollment classes. Each *InkSurvey* question can be designed to probe a particular level of student learning. Then, a menu of two to four questions can be presented to the students and as they complete the first question, they can move on to the next. All students are expected to complete the first, most basic problem. Some students will require the entire time allotted for this series of questions to achieve success on this single question. Others, however, will more quickly
be able to show their mastery of the basic concept and can then begin working on additional problems in the series that enrich their understanding through applications of the same concept at more complex levels or in different contexts. After the class meeting, all students still have electronic access to all of the questions in the set, for the purposes of further study. This makes it possible to effectively accommodate both different rates at which students work and different levels of student comprehension. In this manner, the Tablet PC technology has greatly facilitated differentiated learning in these classes.

3. Increased temptations related to on- and off-task instant messaging, playing games, and off-task internet surfing. The most obvious solution to this difficulty is to limit internet access in the classroom to solely the site needed for the web-based InkSurvey. While this is technologically feasible since the Tablet PCs the students use are school-owned and imaged, it has several disadvantages. First, we ask the students to use a variety of web-based applets in class throughout the semester, which would cause additional administrative issues to “unblock” these sites. Secondly, it does nothing to address the issue of the students playing games. Finally, it does not give the students an opportunity for personal growth in a direction that will later help them in the workplace, where many will face these same temptations.

Student responses to the end-of-semester surveys gave additional insights into this point. Eighty-four percent (84%) favored the above idea of limiting internet access. However, seventy-five percent (75%) of the students surveyed thought the Tablet PCs would distract them less from their learning if the instructor simply asked them to close the Tablet PC when not responding to InkSurvey questions. This would prevent them from using the Tablet PCs to take notes, but help them resist the distractions.

In the student surveys, many student comments echoed this sentiment on the issue: “I think that if people do not want to pay attention in class, then they won’t pay attention in class. If students come to class wanting to learn, then the tablet is not going to distract them from that.” In other words, many felt that the distractions presented by the Tablet PCs were not much different from those of reading the newspaper, daydreaming, dozing, etc.

Once we implemented the technique of activating multiple questions to facilitate differentiated learning (see above), most of these problems with off-task distractions were eliminated.

Student Perspective: Additional Advantages of Using the Tablet PCs

We have already briefly discussed the pedagogical motivation of building our class time around the use of open-ended questions for real-time formative assessment, improved student metacognition, and increased active learning. Beyond this, student surveys revealed other ways the Tablet PCs had improved learning experiences from the student perspective, including being able to ask a question anonymously in class, greater access to school-licensed software such as Mathematica, and the advantage of using powerful note-organization programs during class.
Conclusions

As we transitioned from multiple-choice (clicker) to open-ended questions for real-time formative assessment in two upper-level engineering physics courses, our students encountered difficulties of three types: increased student stress, more obvious differences in rates and levels of student learning, and distractions from the technology. We believe an awareness of these difficulties will help others who try to replace multiple-choice questions with open-ended responses in their classes. Furthermore, we have developed and described some useful strategies for overcoming these challenges. Even in light of these unanticipated student-based difficulties, we see the utilization of Tablet PC technology to facilitate using open-ended questions for real-time formative assessment as a very powerful pedagogical tool that merits further implementation and evaluation.

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Bibliography