

Expanding the Use of Classroom Response Systems (CRS): CRS Integration with In-Class Group Activities in Large Classrooms
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Course Overview: Environmental Geology

Clickers are used in the introductory-level Environmental Geology course, which is designed for non-geology majors. The course is among those that undergraduate students may take in order to fulfill the natural science requirements of the Arts and Sciences College at the University of Colorado at Boulder; as such, the course attracts many non-science majors. The maximum enrollment is 65 students.

During the Fall of 2007, the course met 3 times per week, for 50 minutes per class meeting. The interactive lecture format (without labs or recitations) is based on 5 different modules. Whole-class discussions and Q&A periods between students and instructor were facilitated both with and without i>clickers. Approximately every 3 weeks, near the end of each module, the lecture was replaced with small-group-based in-class activities that ran the duration of the class meeting. These activities were designed so that students built upon the scientific concepts presented in the previous lectures and assigned readings. Homework, writing exercises, clicker questions and exams were designed to assess students' comprehension of the material and their ability to independently analyze environmental issues. Clickers were used during lectures and in-class activities.

Motivation for Using Clickers

Overall motivations for using clickers in this course include:

- (1) to promote engaged student participation and
- (2) to promote active student learning

Specific motivations for using clickers in this course include:

- (1) pre-instruction assessment for students and instructor (i.e., what do students already know before new course material is introduced)
- (2) “hooking” students into new material by making connections with knowledge they already bring to the class
- (3) formative assessment for students and instructor by quizzing students on material covered during the lecture
- (4) application challenge for students by asking them to apply course material to solve an unfamiliar problem; also provides formative assessment for students and instructor

Implementation

Grading Policy

The student use of clickers is one component of *class participation*, which constitutes 15% of the overall course grade. Individual answers to clicker questions were graded differently, according to the type of clicker question posed. Questions that solicited students’ perceptions were worth 2 points each, regardless of what answer a student selected. Questions that asked students to synthesize what they learned were worth 3 points if the student selected the correct answer and 2 points if the student selected the incorrect answer (i.e., 2 points for participation and 1 additional point for correctness).

Frequency

One to 4 different clicker questions were posed during each class meeting.

Types of Questions Asked

Clicker questions were in the form of 5 different types: factual, reasoning, opinion, application, and logistical.

- A **factual** clicker question has a single correct answer; is related to a piece of information or a fact (e.g., definition of a term); the student either knows the answer or guesses (e.g., age of the Earth); and the question can be used to test students' knowledge – before or after material has been covered.
- A **reasoning** clicker question has 1 or more correct answers; is related to concepts (i.e. generalized principle/standard/idea that applies to many cases); the student can reason out the answer by drawing on concepts either previously covered in the course or not; and the question can be used to stimulate, gauge, and assess students' reasoning.
- An **opinion** clicker question has no correct answer; is related to students' impressions, feelings, values, or beliefs; the student might readily answer or might require time for consideration to form an opinion; and the question can be used for sharing and illustrating different perspectives or highlighting diversity of views on a single subject.
- An **application** clicker question has one or more correct answers; is related to facts and/or concepts (i.e., generalized principle/standard/idea that applies to many cases); the student uses/applies previously covered course material (i.e., facts and/or concepts) to a different context or to a practical problem; and the question can be used to provide an opportunity for students to use/apply learned facts and/or concepts. An application clicker question can also be used to promote connection-building in students' cognitive domain (i.e., see how seemingly unrelated facts and concepts are connected to one another).
- A **logistical** clicker question has no correct answer; is related to personal resources, circumstances, etc. (e.g., how many of you own a laptop?); the student can readily answer; and the question can be used to determine student backgrounds for planning purposes (e.g., activities).

One example of each of the above described types of questions is provided below.

- (1) Factual Question: The term water table refers to:
 - (a) Water in the zone of saturation
 - (b) Water in the soil of saturation
 - (c) Boundary between groundwater and surface water
 - (d) Boundary between the unsaturated and saturated zone
- (2) Reasoning Question: Why is there no oceanic crust older than 200 million years?
 - (a) Plate tectonics didn't occur prior to this
 - (b) Spreading ridges ran much more slowly in the past
 - (c) Older oceanic crust has all been subducted
 - (d) No ocean existed before that
- (3) Opinion Question: If you had to decide the fate of New Orleans, would you ...
 - (a) Rebuild the entire city
 - (b) Only rebuild parts of the city
 - (c) Relocate the city
- (4) Application Question: If you had to advise how to get rid of hazardous chemical waste, what would you suggest?
 - (a) Use a secure landfill
 - (b) Use a deep well
 - (c) Equally acceptable
- (5) Logistical Question: How many people own a laptop?
 - (a) Yes, I own one
 - (b) No, I don't own one

Classifying clicker questions under the above 5 types of questions was helpful from instructional and research viewpoints. In the context of the course, however, students were asked to think of the clicker questions in only 2 ways – right/wrong questions (worth a maximum of 3 points) and perception questions (worth a maximum of 2 points).

Format of Asking Polling Process

No single format for polling was consistently used; instead, various different formats were used at different times for different reasons. For example, usually, when an opinion clicker question was posed, students were not provided time to discuss the question with their peers and were asked to directly select an answer. As another example, when a factual clicker question was posed sometimes students were asked to chat about the question with their peers prior to voting. However, sometimes students were asked to directly vote, the results of the poll were revealed and partially discussed, and then students were asked to consult with one another before casting a second vote on the same question. After the polling results were displayed, a whole class instructor-facilitated discussion followed. During this time, the different answer choices were discussed – why did students vote for the answer they did, why did students not vote for other answer choices. These discussions also provided opportunities to actively reinforce lecture material and course objectives.

Results and Conclusions

To evaluate how successful integrating clicker questions in the Environmental Geology course was in promoting engaged participation and active learning, I made and recorded classroom observations for 91% of all class meetings. In addition, I conducted 9 voluntary student interviews and administered a voluntary post-instruction online survey that was completed by 39 students. The data collected focused on student participation, how students valued the interactivity of clicker questions as an aid to learning, and students' self-assessments of what they learned. Learning gains based on comparisons of pre- and post-instruction conceptual surveys were not a part of the data collected because such a survey was being developed during the course of the Fall 2007 semester.

Classroom observations focused primarily on the interactions between the instructor and the students, as well as interactions among the students including: (1) the number and types of questions asked, (2) whether the instructor or a student asked a question, (3) whether a male or female student asked or answered a question, (4) whether the question was a spontaneous, non-clicker question, and (5) the context in which questions were asked and answers or comments were shared in class. These observations allowed for detailed analysis of in-class activities, clicker questions, and spontaneous questions from the students and instructor.

Classroom observations during usual lecture sessions yielded data on 2 different aspects of the lectures that could be used as first-order approximations for the level of interactivity of the lectures and the extent of engaged class participation: the number and types of spontaneous, non-clicker question) asked by the instructor and students and the overall number of student contributions in terms of questions asked as well as answers and comments offered. In general, the larger the number of questions asked is interpreted to mean the greater the level of interactivity.

Student interviews and the post-instruction online survey were used to probe students' perceptions of the clicker questions and their self-assessments of what topics they learned best during the course.

In the post-instruction survey, students were asked how helpful clicker questions were to their learning, with 85% of the students finding perception clicker questions helpful, and 79% finding right/wrong clicker questions helpful to their learning.

In the 35 observed lectures, a total of 670 spontaneous questions were asked. The instructor posed 416 spontaneous questions to her students, and the students asked the instructor 171 spontaneous questions in the large-class setting. More than 1/3 of the instructor questions (36%) were asked during post-polling clicker discussions, typically to solicit comments about each of the choices made by the students.

Of the 171 spontaneous questions asked by the students, 63% dealt with content covered during the lecture for example, points of clarification, how a particular process applies to some other region in the world, and 22% were raised during the instructor facilitated post-polling discussion after a clicker question was asked.

In student interviews, students were asked, "Does having clicker questions help your learning?" All students interviewed answered in the affirmative. Students reported that having clicker questions helped them in at least 2 ways: "it gets me to class" and "it focuses my attention on the things that are important." Also, the majority of students found that the peer discussions about clicker questions were "moderately helpful" to "very helpful" to their learning. Student interviewees who expressed drawbacks to clicker questions most cited the cost of a

clicker (~\$40) and the fact that the clicker was one more item to forget. Many students also said that they would have liked to have had more clicker questions.

To reveal what course material the students thought they understood well after having taken the course, the post-instruction survey asked students to state “1 geosciences topic you really understand and what about the course made it ‘click.’” Twenty-five students provided 1 topic that they thought they understood well. Of these 25 responses, 64% related to ground water (48%) and water contamination (16%); 20% related to the rock cycle and rock formation; and the remaining 16% reflected a mix of volcanoes, waste management, and management of natural resources. Of these 25 responses, 21 included what aspect(s) of the course helped the student understand the topic. According to these results, the aspects of the course that most helped students learn were the in-class activities (43%), followed by the home-work (38%), lecture (33%), clickers and discussion (14%), and reading the textbook (5%).

Overall, the data indicate that clicker questions did promote engaged student participation and demonstrated that students found clicker questions helpful for learning course material. The data, however, do not provide evidence one way or another that student learning gains were influenced by the use of clickers.

Recommended References

Greer & Heaney (2004), Real-time analysis of student comprehension: an assessment of electronic student response technology in an introductory earth science course. *Journal of Geoscience Education*, v. 52, n. 4, September, 2004, p. 345-351.

Beatty, Gerce, Leonard, & Dufresne. Designing effective questions for classroom response system teaching. *American Journal of Physics*, v. 74 n.1, January 2006, p. 31-39.