

Encouraging Class Preparation through Reading Quizzes  
Research in PH201 & PH202, Introductory Calculus-based Physics

Master Teacher Program  
Major Jonathan A. Campbell  
Department of Physics  
U.S. Military Academy  
West Point, New York

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**Are reading quizzes effective in encouraging classroom preparation?  
“Yes. I have started reading, understanding concepts, and learning definitions.”**

Who among us would not want to see students change their behavior and start preparing adequately for class? I embraced reading quizzes (RQs) and became an early fan based on comments like the one above, but just how effective are they at encouraging classroom preparation, and how can I execute a RQ program most effectively?

Peer Instruction (PI), pioneered by Dr. Eric Mazur, Professor of Physics at Harvard University, seeks to increase student understanding of concepts by increasing classroom interaction between students. Rather than focusing on numerical problem-solving, it reorients emphasis onto fundamentally understanding the concepts of science. The immediate critique that students' problem-solving skills would suffer has been repeatedly shown to be incorrect. In fact, by better understanding what is happening conceptually in a problem, students' ability to solve numerical problems actually increases.<sup>1</sup>

As an alternative to classroom lecture with prepared notes that often mimicks the textbook, in which students sit as passive observers of progress through the syllabus, PI seeks to force students to understand and discuss a focused, but non-numeric, problem. Using an automated response system, also known as “clickers,” students commit anonymously to an answer and can see how the class as a whole voted. Based on the level of student understanding, the teacher can proceed in various directions. If results are good enough (generally, greater than 90% correct), discussion can move onto another topic after a student explains how and why they chose their response. If results show a certain group of students understand the problem (generally between 50% and 90% correct responses), students have the opportunity to discuss among themselves and convince their neighbors why their response is correct or listen to the reasoning of their partners. If results are poor enough (generally less than 50% correct responses), the teacher can choose to provide a mini-lecture on the topic, before allowing students to deal with the concept problem again.

***“The clickers...were a useful tool in expressing an opinion but without the embarrassment of everyone knowing you had no clue what you were talking about. Also, when we were told to “convince” each other it helped us explain to each other why we thought our answers were correct.”***

Pre-class reading assignments are a staple of education at the United States Military Academy, and they are a key ingredient to the success of PI. Because class time is being devoted to something besides the *tour de force* of traditional instruction, and because the effectiveness of PI requires a certain critical mass of knowledge among students, a basic level of definitional understanding by the students is essential. Though they may not have understood the fine points of the assigned reading that the answers that the concept questions hinge on, students that come to class prepared with the basics such as definitions and an honest attempt to understand the heart of the lesson provide the basis for the group to move toward mastery of the topic. Under the adage that students do what teachers check, Mazur insists that pre-class reading, assessed by RQs, is a required component of the PI methodology's success.

#### Implementation

Mid-way through the Fall 2006 semester, all introductory physics teachers in the USMA Department of Physics received a set of radio-frequency clickers and the accompanying software (TurningPoint) to allow easy implementation of a personalized response system through a medium with which they were already familiar, Microsoft Powerpoint. An example concept question with student responses using clickers is in Figure 1.

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<sup>1</sup> Eric Mazur, *Peer Instruction: A User's Manual* (Prentice Hall, Upper Saddle River, NJ: 1997),

Reading Quiz (1 pt) The orange lines are \_\_\_\_\_, and the blue indicates \_\_\_\_\_.

(a) (b) (c)

40% 1. equipotential surfaces; electric field lines  
 0% 2. electric field lines, equipotential surfaces  
 20% 3. points at the same voltage; electric field lines  
 0% 4. Both 2 & 3  
 40% 5. Both 1 & 3  
 0% 6. None of the above.

**Figure 1.** Example reading quiz

During my first-semester of using clickers and PI (also my first semester in the classroom), I felt that concept questions were very effective in getting students to grapple with difficult concepts. Having started the course without clickers, three-quarters of my students expressed the opinion that clickers were a “worthwhile addition to the course.” In free-text response, numerous students expressed positive opinions about voting in class, such as “it was a nice break,” when asked what part of the course they especially liked. However, the course-end feedback also indicated that over half of my 63 surveyed students focused almost solely on the numerical homework problems (administered online via *WebAssign*), and spent less than 20% of their time on other study requirements such as reading. Since the textbook is the primary resource students have for the course, and since understanding basic concepts before class is essential for the success of PI, I was deeply disturbed by comments such as “sometimes I feel the reading is pointless because it doesn’t help me with *WebAssign* [online homework].” This implied that success in a course about science and concepts could only be achieved through problem-solving, and that students were not coming to class equipped to receive the maximum benefit from PI.

### Implementation

Attempting to fully adhere to the PI methodology, I began administering RQs in four sections of PH202 in the Spring of 2007. Since students had not seen this form of assessment during their first semester, I made a concerted effort to “sell” the change to each class. I assigned a small number of points to each reading quiz, with the total of the semester amounting to four percent of the student’s final grade. These points came at the expense of instructor-administered quizzes, generally given immediately after covering a topic and allowing guided practice. These instructor quizzes have a reputation for being difficult, and in the previous semester, I found that my 67 students’ instructor quiz scores were over 10% lower than their end-of-semester grades. I used this fact, coupled with a theme of rewarding preparation for class via RQs, rather than penalizing learning shortfalls via instructor quizzes, to obtain student “buy-in” to RQs.

My initial attempts at RQs suffered from various deficiencies. First, I assigned between one and five points to each quiz, based on my own prejudice as to the question’s difficulty and relevance to the lesson learning objectives. I quickly abandoned this practice, as I found that it overweighted challenging concepts and underweighted basic ones, which contradicted my explicit purpose, to reward basic pre-class preparation. About the mid-point of the semester, I found that

the scores on RQs were lower than what I had experienced previously with instructor quizzes and that students with an overall grade of A+ in the course had reading quiz results that were not reflective of their understanding of the material (as measured by the overall grade). Based upon that, I found that about one in every six reading quiz questions should be given as a bonus point. This ratio of 1 bonus point opportunity for every 5 regular points was enough to bring results in line with student's overall level of comprehension and made up for a badly worded question or a question misinterpreted by a student. As one put it on a survey: "I find that I can miss multiple choice questions that I understand but misinterpret." This last concern is especially important in that the reading quiz evaluation occurs right after the students' first exposure to the material, when the student has had minimal exposure to the style and representation of the lesson's concepts, and is thus more likely to misinterpret a question.

Setting the difficulty of the reading question at the right level is an on-going challenge. I found it too easy to fall into the mode of writing a question that I would be happy that a student could correctly answer at the end of class or during a traditional exam. But since RQs are administered at the beginning of a class and come early in the exposure timeline of a topic, I found it necessary to focus on a common source of questions that I articulated repeatedly to my students:

- Definitions. In the course outline, each day's lesson has a few terms (typically 3-5) students are responsible for knowing. These became the first source of RQ questions. For example, constructive and destructive interference (of waves) were two definitions which a student should be able to understand from textbook exposure.
- SI (metric) units. These are foundational to science, and rarely did I pass up an opportunity to ask students to associate terms and units (e.g. Force is measured in Newtons).
- Textbook diagrams. These illustrations are often the heart of a science textbook, and having done the reading, it is fair to ask a student to distinguish between, for example, an electric field and an equipotential surface, using a diagram straight from the textbook.
- Textbook Checkpoints. Our textbook uses a conceptual understanding problem embedded periodically in the reading to allow students to check their level of comprehension. Although these are often challenging questions that focus on the nuances of a concept, the answers are provided in the textbook, and this resource is continually praised by teachers as being very worthwhile.

Focusing consistently on these question sources let students develop a comfort level with what they were expected to know from the reading.

I originally included questions such as "which of these diagrams or topics was not in the assigned reading," but I abandoned them. One student pointed out that he often worked ahead, so that he understood the material but two weeks had elapsed since he had read the assignment, and he couldn't remember which picture wasn't in the reading, although he could talk intelligently about the picture. Another mentioned that RQs should "assess us on what we know about physics. There are many times when I just do practice problems instead of reading the reading." I readily agreed that questions should focus on understanding, not misguided attempts at proving whether or not a student had superficially looked at the textbook.

In practice, I rarely discuss the results of a reading quiz. When the correct answer is displayed, I allow time for students to see it, then move on. Occasionally, a student will have a question, and I will either let another student explain why an answer is correct, or acknowledge and save the question to be referred to later during class. When I have discussed the reading quiz questions, I've found that it destroyed the purpose of RQs in that students were willing to lose a few points and have basic knowledge spoon-fed to them.

I also found that students would, of course, prefer review quizzes consisting of slightly harder questions about material from previous lessons. Since these undermine the stated purpose (encouraging class preparation) by encouraging paying attention in previous classes instead, I limit them to no more than 1/3 of the total RQ questions, and generally use them to review material from previous lessons which is directly applicable to the new topics—a question requiring them to apply previously-learned material in a scenario that will occur again in the context of this lesson.

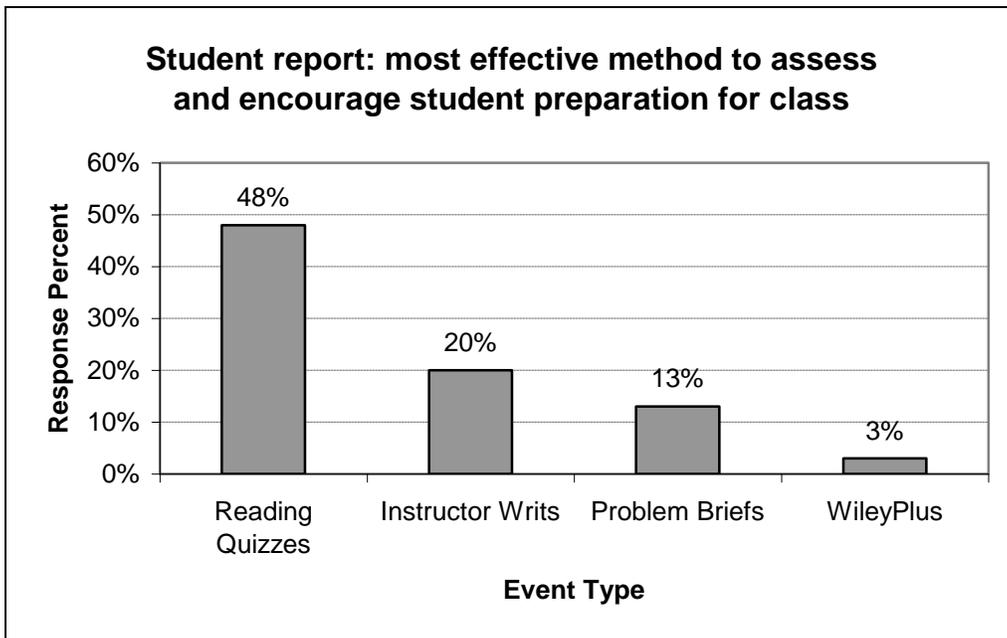
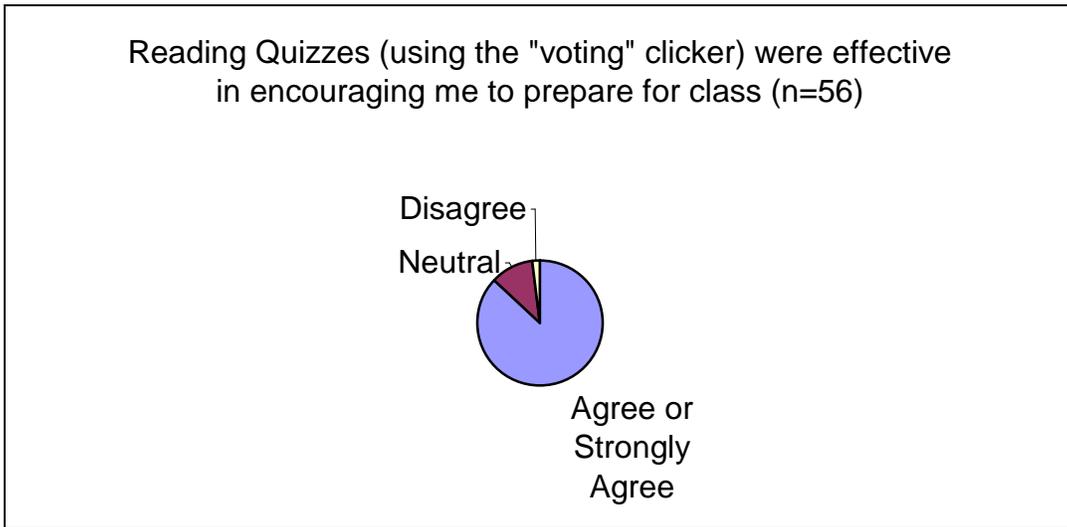
## Results and Assessment

My initial results and impressions of RQs were quite positive. A sampling of cadet feedback indicates why:

**“Reading quizzes at the beginning force me to come to class more prepared.”**

**“The reading quizzes helped me to learn physics because it forced me to do the reading every night.”**

**“I thought the reading writs helped to reinforce the concepts that we read the night before.”**



But, when examined from the larger perspective of what allows students to learn physics well, RQs rate well down in 5<sup>th</sup> place, behind coach problems/lessons, annotating the Physics Reference Card, concept slides (voting) & sample problems, and class notes. They did rate one step higher than homework problems or the assigned readings.

After three semesters of developing, administering, and modifying RQs, including adoption and subsequent abandonment of the technique by numerous other instructors, I have come to the conclusion that RQs are effective only so far as they encourage students to prepare for class. The difficulty level of questions is hard to get right. If questions are too easy such that a student who doesn't prepare earns a satisfactory grade, then why bother preparing? If they are too hard, the result is frustration and eventual abandonment of class preparation—why bother preparing if I'm not going to do well on the RQs anyway?

Although it would be compelling to examine whether scores on RQs had any correlation with final assessment scores or even a causal relationship, I chose not to look into this data because it would be impossible to isolate the effects of the reading quiz from subsequent influences. Because RQs are at the beginning of the cycle of student exposure to material, and because they are followed by a full classroom interaction, follow-on problem-solving sessions and student efforts at studying, the effects of the reading quiz will get lost among many contributing influences. They are a success if students come to class any more prepared than they would be otherwise, because this allows class time to be spent more effectively on difficult-to-grasp topics, rather than fundamentals such as terminology and units.

**“Reading quizzes are a brilliant idea—they allow instant feedback to students and the instructor concerning problem areas.”**

This student's comment captures my ultimate conclusions on the topic. Reading quizzes are good at allowing the teacher a quick snapshot of the preparation level of the students, but they do very little to encourage classroom preparation.

### **Future Work**

Ultimately, RQs are a tool to assess classroom preparation more than they are a tool to encourage that preparation to occur. Examining written homework is equally effective at checking pre-class preparation, as is consistently pitching the class to a level that requires preparation. I believe RQs were most effective in encouraging preparation when the painful alternative (instructor quizzes) was a recent memory (at change of semesters) and the technique (RQs) was novel (clickers were new technology). I am ultimately not convinced that they really increase student's preparation time or effort. I find their value to me as a teacher now to be most useful in deciding what level of understanding the students have on a topic at the beginning of a classroom session, setting the baseline for our discussion. In fact, Mazur himself has moved away from them, instead providing take-home questions to be answered from the reading.<sup>2</sup> As I move from being an instructor, prohibited by policy from assigning additional homework, to a course director charged with designing the pedagogical path, to include assignment of homework, I plan to incorporate my experience over 3 semesters of RQs to design questions and topics that are designated for pre-class preparation and other questions and topics for in-class discussion.

The cadet comments about assessment are hard to ignore, and suggest my focus as a course director.

**Advice for someone taking this class next year: “Don't worry about the readings of the book—they're a waste.”**

**...[I] concentrated too much on concepts when problems are the main thing we are tested on.**

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<sup>2</sup> Catherine H. Crouch, and Eric Mazur, “Peer Instruction: Ten Years of Experience and Results,” *American Journal of Physics* 69, no. 9 (September 2001), 970-977.